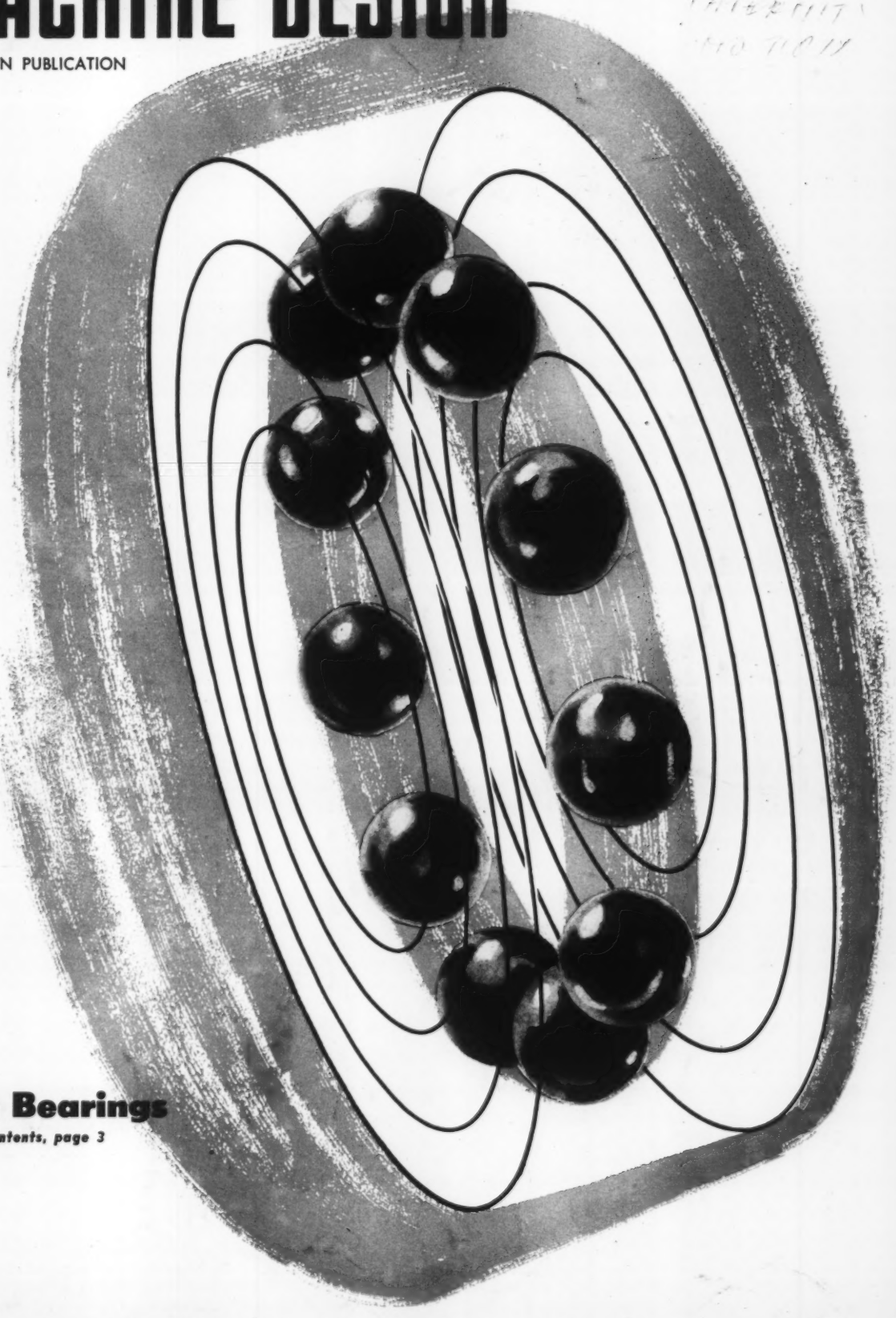
621 R-7

SEPTEMBER 20, 1956
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Ball Bearings

Contents, page 3

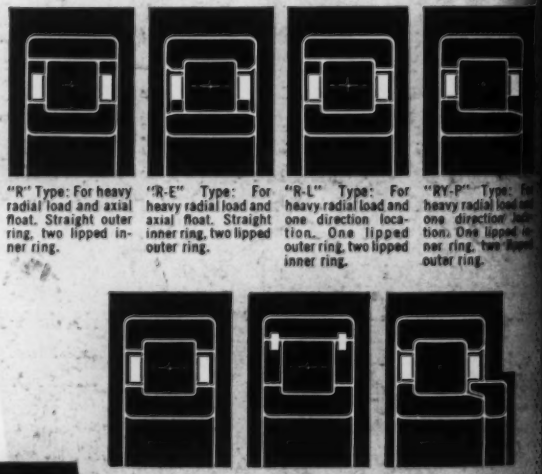
For Greater Load Carrying Capacity in Minimum Space...

NORMA-HOFFMANN *Precision* Roller Bearings

If your bearings must operate under such severe conditions as high speeds, heavy loads, temporary overloads, shock or vibration, then *Norma-Hoffmann* Precision Roller Bearings are your solution. Available in a wide range of both metric and inch sizes from 10 millimeter bore upward.

Compare These Advantages

1. Extra Heavy Radial Load Capacity Plus Resistance to Shock and Vibration.
2. Lower Friction Coefficient under Heavy Load.
3. Speed Ability Equal to Any Ball Bearing, Size for Size.
4. Shaft Expansion Allowed without Looseness in Housing.
5. Weight Saving Possible by Use of Smaller Sizes or Lighter Series.
6. Interchangeable with Single Row Metric Ball Bearings.



"R" Type: For heavy radial load and axial float. Straight outer ring, two lipped inner ring.

"R-E" Type: For heavy radial load and axial float. Straight inner ring, two lipped outer ring.

"R-L" Type: For heavy radial load and one direction location. One lipped outer ring, two lipped inner ring.

"RY-P" Type: For heavy radial load and one direction location. One lipped inner ring, two lipped outer ring.

"R-LL" Type: For moderate radial load and two direction location. Two lipped inner and outer rings.

"R-RR" Type: For maximum radial load at low speed. Full roller retainerless type with snap rings.

"RY-B" Type: For heavy radial load and two direction location. Two lipped outer ring, one lipped inner ring and separable guide ring.

NORMA-HOFFMANN BEARINGS
BALL • ROLLER • THRUST

NORMA-HOFFMANN BEARINGS CORPORATION
Founded in 1911 • STAMFORD, CONNECTICUT

FIELD OFFICES: Atlanta • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Kansas City • Los Angeles • San Francisco • Seattle

Circle 501 on page 19

YOU ASKED FOR IT

Answering your request is our pleasure. Whether for a special purpose valve or—in this case—the front cover of the ROSS EnginAIR, our bi-monthly technical publication, a re-print of which so many of you have asked for. Additional reprints on request.

Ross OPERATING VALVE COMPANY
109 E. GOLDEN GATE AVE. • DETROIT 3, MICHIGAN

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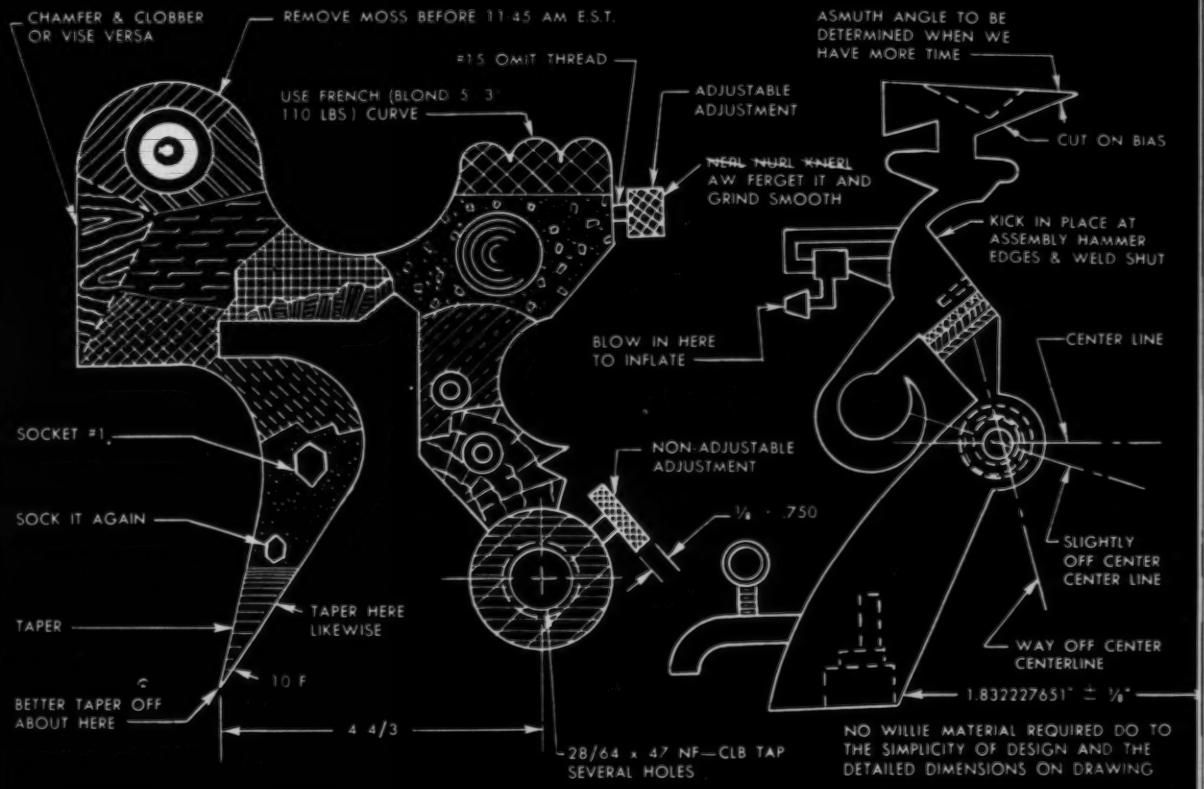

CHAMFER & CLOBBER OR VISE VERSA
REMOVE MOSS BEFORE 11:45 AM E.S.T.
#15 OMIT THREAD
USE FRENCH (BLOND 5' 3" 110 LBS) CURVE
ADJUSTABLE ADJUSTMENT
NEAL NURL KNERL A.W. FERGET IT AND GRIND SMOOTH
ASMUTH ANGLE TO BE DETERMINED WHEN WE HAVE MORE TIME
CUT ON BIAS
KICK IN PLACE AT ASSEMBLY HAMMER EDGES & WELD SHUT
BLOW IN HERE TO INFLATE
CENTER LINE
SOCKET #1
SOCK IT AGAIN
NON-ADJUSTABLE ADJUSTMENT
⅛ - .750
SLIGHTLY OFF CENTER CENTER LINE
TAPER
TAPER HERE LIKEWISE
WAY OFF CENTER CENTERLINE
10 F
BETTER TAPER OFF ABOUT HERE
4 4/3
1.832227651" ± ⅛"
28/64 x 47 NF—CLB TAP SEVERAL HOLES
NO WILLIE MATERIAL REQUIRED DO TO THE SIMPLICITY OF DESIGN AND THE DETAILED DIMENSIONS ON DRAWING

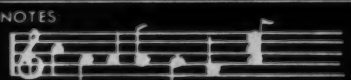
CAUTION
KEEP UPPER BOTTOM RIGHT HAND CORNER OVER ABOUT ⅛ LOWER THAN LEFT HAND CENTER CORNER WHICH SHOULD BE DOWN A LITTLE HIGHER THAN MIDWAY APPROXIMATELY

INSTRUCTIONS
A. DIAMETER WAITING APPROVAL OF SOME TWO BIT CLERK IN THE OFFICE OF SHAPE STANDARDIZATION

THIS IS HOW TWO LINES OF PRINTING LOOK WHEN PRINTED UPSIDE DOWN

PREPARED BY: Ross OPERATING VALVE CO.

NOTES

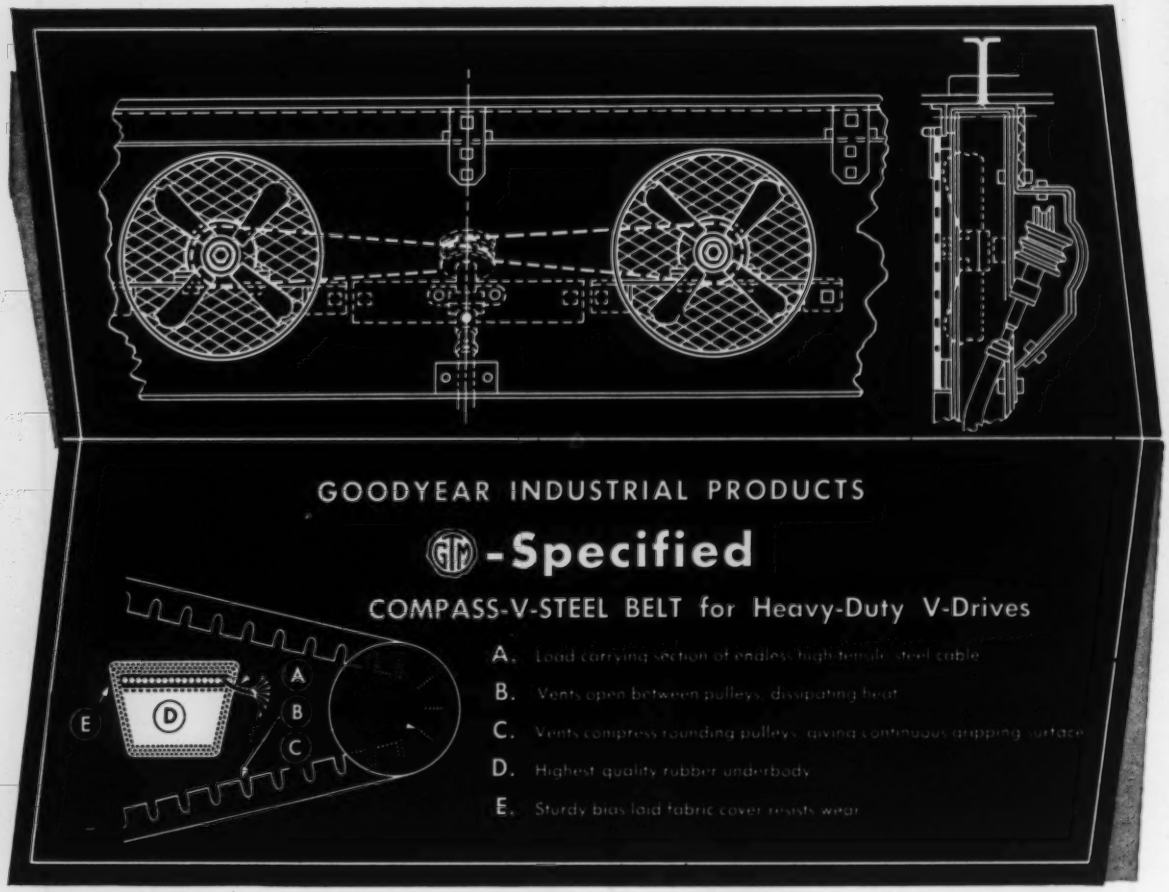


ANY SIMILARITY BETWEEN THE MACHINE AND ANY IDENTICAL MACHINE IS PURELY INCONSEQUENTIAL

SPRING FEVER—DRAFTSMAN'S STYLE

AE | LH | EM

Circle 504



NO BREAKDOWN THROUGH BELT FAILURE

in 2 years on 6,000 drives

BLUEPRINTED above is the tough, quarter-twist drive on the air circulators of a refrigerated railroad car. Two such drives are located over the ice bunkers at the ends of the car. Their job is to equalize the temperature throughout the car by blowing cold air toward the center. They must be reliable, since any breakdown could mean costly damage to a perishable cargo.

To help them design the most dependable drive possible, a bunker maker called in the G.T.M. — Goodyear Technical Man — who recommended a change in sheaves and the use of COMPASS-V-STEEL Belts. Today, after over two years of across-the-country service, no breakdowns because of belt failures have been reported on 3,000 cars — 6,000 drives — 12,000 belts.

If you need a truly reliable V-belt for a drive involving heavy loads, shock loads, speeds of 10 to 10,000 feet, limited space or unusual heat, call in the G.T.M. or your Goodyear Distributor. Let him give you the full story on COMPASS-V-STEEL Belts — the stronger, more efficient belts that have proved themselves on over 5,000,000 critical drives. Or write Goodyear, Industrial Products Division, Akron 16, Ohio.

YOUR GOODYEAR DISTRIBUTOR *can quickly supply you with Hose, Flat Belts, V-Belts, Packing or Rolls. Look for him in the yellow pages of your Telephone Directory under "Rubber Products" or "Rubber Goods."*

Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

September 20, 1956
Volume 28—No. 19

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Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1956 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

When requesting changes of address, etc., please allow four to six weeks for processing.

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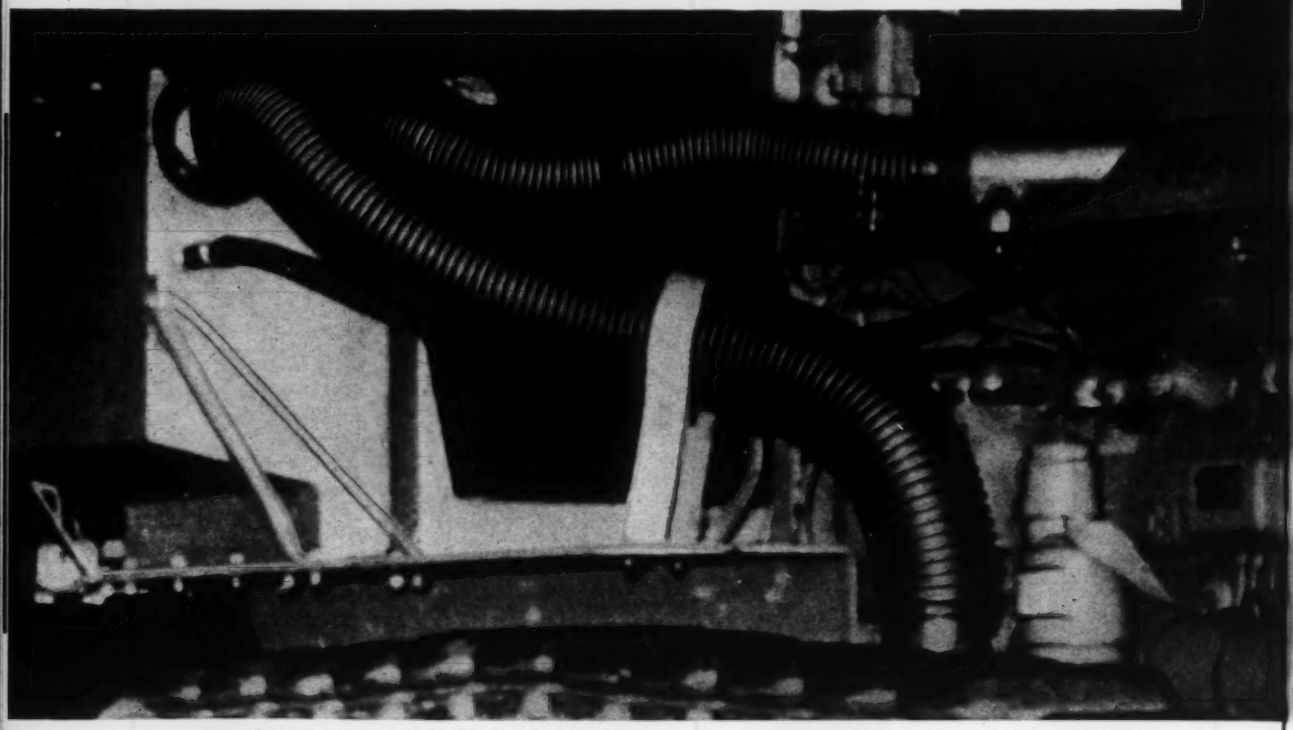
Where you convey gases

and have problems of vibration, misalignment, moving parts or cramped spaces



3″ and 4″ I.D. American Flexible Stainless Steel Hoses used to convey hot exhaust gases on this Caterpillar D2 Diesel Tractor, equipped with Exhaust Conditioner, used in underground, hard-rock mining operations.

Get more service hours per dollar with American Flexible Metal Hose

Famous quality construction of American Flexible Metal Hose offers you the security of trouble-free, leak-proof service in conveying gases, whatever your needs. Proof of this is American's enviable record—in thousands of applications—for the pressure-tight conveyance of air, oxygen, hydrogen, nitrogen, acetylene, propane, butane, Freon, ammonia, and many other gases under both high and low pressures.

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Available in a wide range of diameters in tough, corrosion-resistant bronze, steel, supernickel, brass, stainless steel or other metals, American Flexible Metal Hose delivers the very highest *service hours per dollar*. You can order complete assemblies with end fittings attached—made to your specifications and ready for immediate installation.

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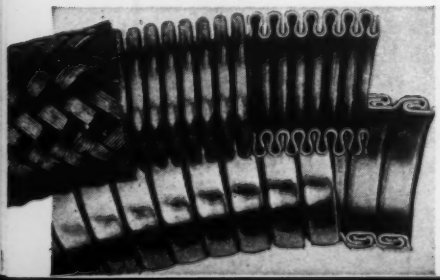


BASIC TYPES

Seamless corrugated and Strip-wound. Both types available in a wide range of sizes and styles in any workable metal. Furnished with or without end fittings attached.

WHEREVER CONNECTORS MUST MOVE

AMERICAN FLEXIBLE METAL HOSE AND TUBING

AN **ANACONDA**® PRODUCT

Circle 506 on page 19

Engineering News Roundup

Licensing Agreement Announced By Business-Machine Firms

NEW YORK, N. Y.—International Business Machines Corp. and Sperry Rand Corp. have entered into a nonexclusive licensing agreement to exchange licenses to manufacture punched-card accounting machines and electronic data-processing machines under their respective patents and patent applications in existence as of October 1, 1956.

The two companies also agreed upon a procedure for settling patent interferences now pending in the United States Patent Office and arranged to exchange technical information with respect to punched-card accounting and electronic data-processing machines announced or released to production prior to October 1.

Micro-File Performs Own Searches Automatically

Punched Tape Tells It What To Look For

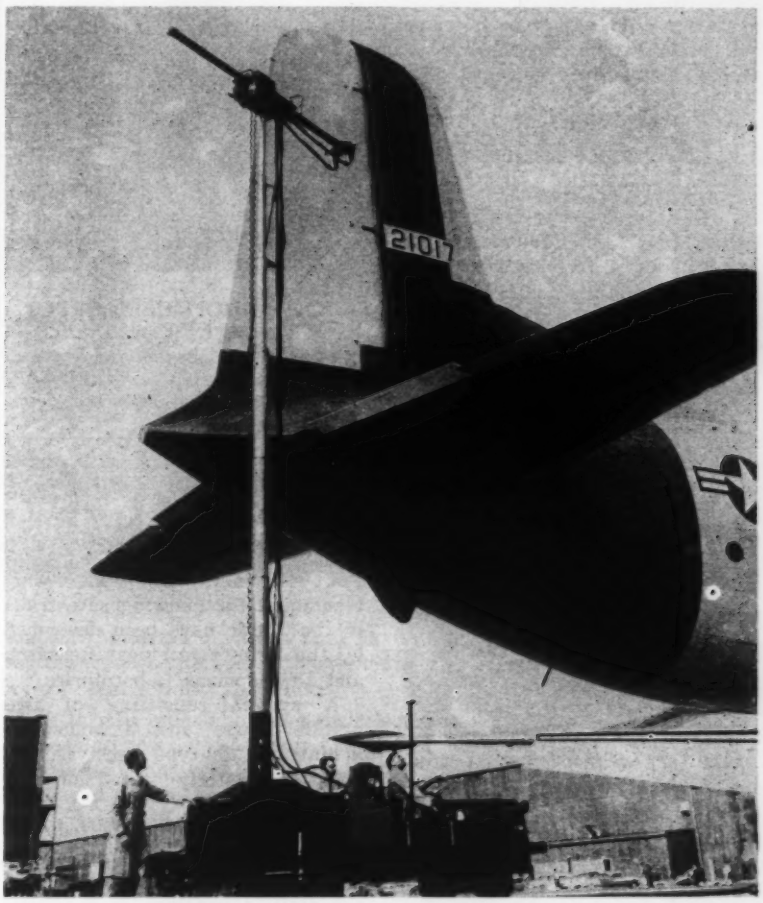
WASHINGTON, D. C.—A microimage data storage and retrieval device recently developed at the National Bureau of Standards provides rapid access to any one of 10,000 information-containing frames recorded in miniature on a 10-in.-square sheet of microfilm.

The instrument operates on a continuous basis; it automatically searches the microfilm and photographically prints out one frame every two seconds.

The machine is particularly applicable where large volumes of data must be assembled in a predetermined sequence from a master random file. Information may be in the form of pictures, drawings, fingerprints, sets of numbers, letters, or other symbols, or even single stages of electronic circuit diagrams. Quantity and kind of data is limited only by the size of the individual frame, 1/10-in. square, and the photographic resolution of the film emulsion.

Input to the machine is from a perforated teletype tape containing the coded locations of the desired frames in the order in which they are to be printed out. The assembled data produced by the machine comes out on a 10-in. wide strip of photo-sensitive paper of any required length. Individual frames are enlarged to ½-in. squares.

The instrument is essentially a combination of digital computer electronic circuitry and a pair of



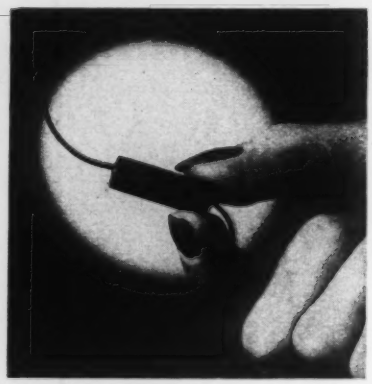
MAST-MOUNTED AND MOBILE, this X-ray equipment was developed by Douglas Aircraft Co. to facilitate inspection of any area on finished planes. The unit consists of a truck chassis 15 ft long on which is mounted a 160 kv X-ray machine. A telescoping mast, hydraulically-operated, can raise the X-ray boom 40 ft. The boom extends 10 ft and rotates 360 degrees.

precision servomechanisms that search X and Y axes of the matrix.

Although the machine was primarily designed as an outscriber for obtaining programmed printing from a large file of negatives, it can temporarily be set up as an inscriber to prepare its own matrices of 10,000 frames each. Using the same machine to prepare a matrix insures that each frame will be accurately located whenever it is subsequently used.

Solid Electrolyte Battery Is Small, Long-Lasting

PARMA, O.—A new solid electrolyte battery claimed to have practically unlimited shelf life has been developed by National Carbon Co. Designed for low-current applications,



the battery weighs less than 1 oz, and is made primarily of silver, silver iodide, and vanadium pentoxide.

Extensive laboratory tests have indicated that the solid electrolyte battery should give up to several decades' continuous service in applications such as maintaining a charge on capacitors in electronic circuits.

Only 1/3-in. in diameter and 1 in. long, the battery weighs ¼-oz, and consists of 200 paper-thin cells. It is rated at 95 v. A continuous current drain of 10 micro-microamperes can be maintained, with flash currents in the microampere range.

The battery can withstand temperatures ranging from −70 to 170 F with no appreciable change in voltage.

MULTIMISSION HELICOPTER, recently delivered to the Marines, is the HOK-1 made by Kaman Aircraft Corp. The new craft has intermeshing rotors powered by 600-hp Pratt and Whitney Wasp engines. The Marines will use the HOK-1 for cargo carrying, medical evacuation, personnel transportation, observation, search and rescue.

Charged Wires Mark Arctic Trails

FORT BELVOIR, VA. — Electronic techniques for marking safe trails in the Arctic have been developed by the Army's Engineer Research and Development Laboratories.

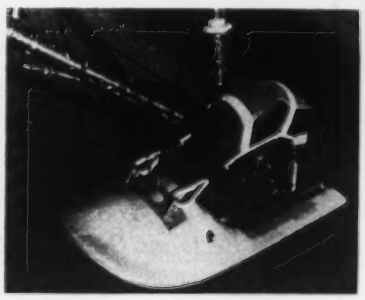
A system consisting of two parallel wires and a vehicular-mounted radio-type receiver has been successfully tested on the Greenland Ice Cap.

Alternating current is fed into the wires, which are buried beneath the snow on either side of the trail. A receiver on a vehicle following the trail detects the current in the wires.

Indicators in the vehicle give the driver his position within the trail. Warning devices alert the driver when the vehicle gets out of bounds and crosses a trail wire.

Poor visibility during the Polar night, snow storms and summer fog make free movement over the ice cap virtually impossible. Travelers face the possibility of getting lost and falling into hidden crevasses.

The development of electronic techniques marks a giant stride forward in overcoming these hazards. The electronic trail is now being extended over a hundred miles on the ice cap. A simplified one-wire trail-marking system which may reduce installation and maintenance costs is also under consideration.



"BEAR-PAW" LANDING GEAR fit over regular wheels of the Kaman HOK-1 to enable operations in mud, snow and sand.

Front Cover

Ball bearings running at high speeds and temperatures require extra attention to lubrication. In his article on Page 114, T. E. Rounds tells how to design the lubrication system for such bearings and, incidentally, provides an excellent theme for cover artist George Farnsworth.

FOR POWER
to do the job
FOR CONTROL
to do it right
FOR PERFORMANCE
that saves you $

Oilgear Fluid Power Systems
FOR HOT PLATE PRESSES

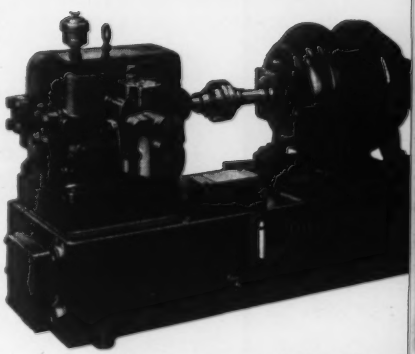
Many outstanding manufacturers of hot plate presses for the woodworking field, as well as makers of heavy duty presses in other fields, have standardized on Oilgear tried and proven "Fluid Power" pumps, cylinders and valves.

Oilgear systems on Veneer and Plywood Presses provide an adjustable working pressure to suit the work performed—a variable ram speed—automatic reduction of pump stroke and power input when pre-set pressure is reached—maximum pressure indefinitely without excessive heating or power loss. Low maintenance cost and high efficiency coupled with use of power only in proportion to the resistance of the work make their operation very economical. Simple, semi-automatic or full automatic controls are easily applied.

You get controlled, variable high speed for closing and opening press. You can vary the force to suit the material processed. You save a high percentage of power and reduce heat and wear during the curing time. Your Oilgear system will be simple, easy to install, and trouble-free. Investigate these and other operating values inherent in Oilgear pumps, cylinders, and valves. They have proven successful for over a quarter century on other tough applications.

Talk to mill men who have installed Oilgear and you will hear why they are enthusiastic about its ability to save time, money and work. Then write to our district or home office about Oilgear for

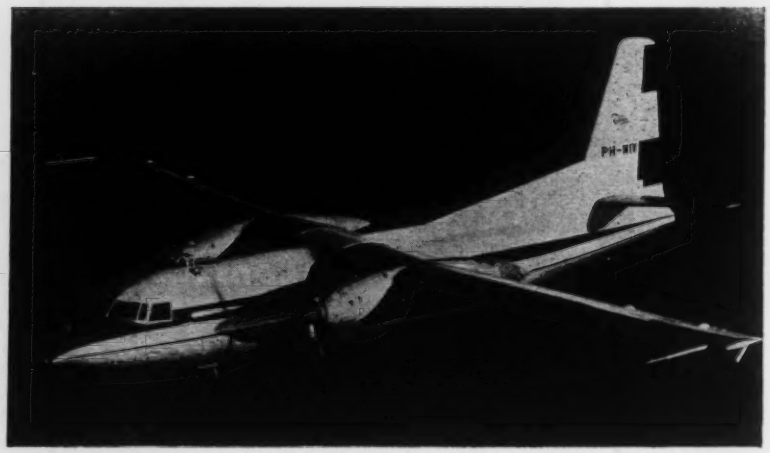
- Carriage Drives
- Gang Saw Feed Rolls
- Set Works and Holding Dogs
- Turners
- Niggers
- Barkers
- Edgers
- Haulers
- Conveyors
- Veneer Lathes
- Surfacers
- Hot Plate Presses
- Baling Presses
- Paper Machine Drives
- Calender Drives
- Winder Drives
- Unwinder Drives
- Hold-down Systems



Standard one-way variable delivery pump, type D.P. Automatic pressure unloading control, direct-connected electric motor, mounted on reservoir base.

Oilgear Fluid Power

Circle 507 on page 19



FRIENDSHIP F-27 is being introduced by the Aircraft Div. of Fairchild Engine and Airplane Corp. specifically for short and medium-range commercial service. Two Rolls Royce Dart Propjets give the Friendship a cruising speed of 280 mph. Takeoff distance is 3850 ft and effective range is 2250 mi. The Friendship has 95 ft wing span, 76 ft length and 26½ ft height. Another new Fairchild transport, the M-185, will be powered with four jet engines. Also a high-wing monoplane, the M-185 will be smaller than the Friendship but twice as fast.

Device Rides Beam of Light To Measure Runway Roughness

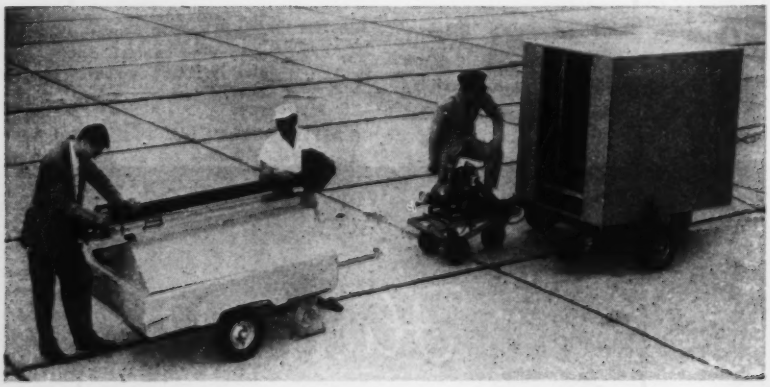
KANSAS CITY, MO.—A new device that measures the roughness of a runway surface has been developed recently for the Air Force by the Midwest Research Institute.

As airplanes become heavier, and as they taxi for takeoff at higher speeds, they inflict more and more damage to runways. In turn, the runways set up damaging vibrations in the planes.

As a first step in preventing this double damage, the new device takes a profile of runway surfaces.

Operation of the device involves a zirconium arc, located in a stationary unit at one end of a runway. From the arc, a fixed beam of high-intensity light, 4 in. in diameter, extends the length of the runway. A set of photo-electric cells, in a box arranged to move up and down, locks onto the light beam and rides it as the vehicle travels over the runway.

Every 6 in. along this course, a magnetic tape recorder charts the vertical distance from the horizontal beam of light to the runway surface, thus producing a profile. The profile is reduced to a simplified series of numbers, fed



Topics

Two treads are better than one, according to General Tire & Rubber Co., developer of a dual-tread tubeless tire. Tread of the new tire is designed to give the effect of two separate, narrow tires on each wheel.

• • •

Method of coating molybdenum turbojet engine parts to resist corrosion has been developed. A thin sheath of a metal alloy is cast around the molybdenum part to protect it from oxidation caused by the intense heat of the engine.

• • •

Flat television tube developed by a Frenchman has received the first American patent covering such tube construction. It is adaptable for either color or black and white and provides for very large viewing surfaces.

• • •

Self-regulating clocks are scheduled to make their debut in several 1957 automobiles. The clocks, made by Westclox, adjust automatically to run faster or slower when the hands are set ahead or back.

• • •

Air-conditioned farm tractor with a glass-enclosed cabin has been introduced by Cockshutt Farm Equipment Inc. The cabin also has a heater and a push-button radio. How're they gonna keep 'em away from the farm after they've seen this?

• • •

A new week—Automation Week—has been proclaimed by the mayor of New York. It will occur November 26 to 30, at the same time as the Third International Automation Exposition.

• • •

A helicopter flight simulator is being built by Melpar Inc. for the Army. Cockpit motion, rough air and other flight problems will be simulated. Use of the simulator is expected to reduce the cost of pilot training, as well as aid in the development of helicopter instrument flying.

• • •

Passenger No. 300,000,000 recently was carried by the nation's scheduled airlines. The 100 millionth passenger flew in 1950; the 200 millionth, in 1954.

Circle 508 on page 19→

Yours.. for the asking

The proper material for sintered bronze or iron bearings has always been a major problem to design men. Now for the first time a chart has been engineered, clearly showing the complete chemical, mechanical, and work characteristics of a wide range of sintered bearing materials. The best material for most applications can be selected by a draftsman in a matter of minutes. Only requests on company stationary will be honored.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

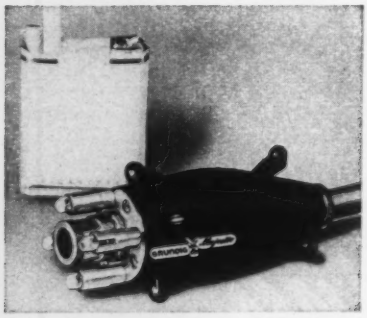
POWDER METALLURGY BEARINGS + PARTS

into a computer, and transformed into a curve.

Ways to apply the same techniques and equipment to roads and vehicles are currently being studied. Highway engineers could determine surface conditions critical to roadbed life. The technique and equipment could help eliminate fatigue-type structural failures encountered in vehicles—the principal item of maintenance in tank trailers, for example. The same type of surface roughness studies could contribute to reducing operator fatigue in commercial and private vehicles.

Tiny TV Camera Provides Inside Views

CHICAGO, ILL. — The Peepsqueek television camera, measuring less than 6 in. long and 1⅞ in. in diameter, can be used for internal inspection of previously inaccessible areas. It is equipped with



two sets of spring-loaded guide rollers and can travel through pipes, tubing and walls that have an inner diameter of 2⅜ in. or more and a bending radius of 14 in.

The remotely controlled camera contains a Miniresistron and a number of subminiature tubes that serve as amplifying elements. A conical mirror accessory can be mounted ¾-in. ahead of the lens combination to reflect the image of the inside walls. The image received can be magnified up to 20 times.

The Peepsqueek is manufactured in West Germany by Grundig Radio-Werke GmbH and is marketed in this country by Majestic International Corp.

Roundup Feature Report

Trend Still Up in Engineers' Starting Salaries

Schools Report
8 to 10 Per cent Gains

The trend of the past several years toward higher starting salaries for new engineering graduates was continued during the recruiting season of 1956. A MACHINE DESIGN survey of representative engineering colleges shows that 1956 average salaries in all engineering curriculums are 8 to 10 per cent higher than the corresponding 1955 figures. Reports were received from Lehigh University, Northwestern University, Case Institute of Technology, University of Pennsylvania, and Purdue University.

Averages of monthly salaries for all engineer graduates in all five schools occurred in the range $410-435. These were $20 to $45 higher than offers accepted by the 1955 class.

Average salaries reported for mechanical and electrical graduates were between $420 and $445. In several cases the averages for the two were the same. Where differences occur, the electricals have an edge not greater than $10 per month.

Illinois Institute of Technology confirms the trends, and reports an average of $474 for aeronautical engineers, substantially above all other curriculums. Also confirmed by Illinois, the monthy salaries for civil engineering graduates show improvement over past years. Civil engineer averages this year range from $413 to $439.

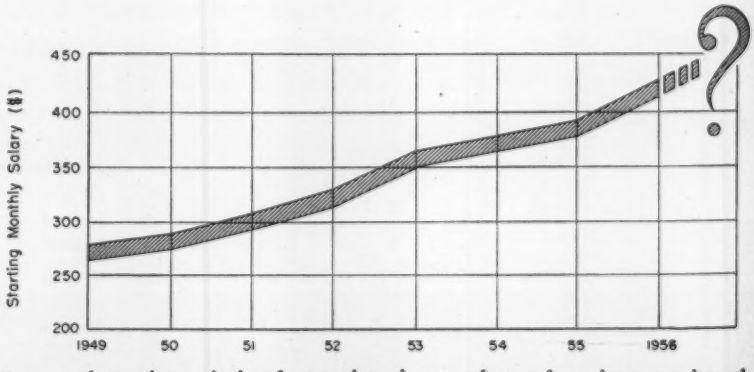
A general comparison of the averages for all engineers and all other graduates makes $400 per month a dividing line. Arts and business graduates accepted average salaries less than that while engineers earned more. Statistics for the 1956 class at Lehigh are nearly representative for all the schools surveyed.

Average Starting Salaries: Lehigh Graduates

Curriculum	1956	1955	1954
Mech. Eng.	$420	$377	$361
Elec. Eng.	426	396	374
Ind. Eng.	407	386	370
Eng. Physicist	428	396	367
Civil Eng.	413	375	373
Chem. Eng.	410	378	352
Chem.	421	382	365
Met. Eng.	420	378	365
All Eng.	418	383	366
Arts	380	354	334
Business	377	342	335
Total	392	371	358

Taking note of the trend in engineering salaries, the U. S. government has also increased the salaries of new graduates as well as experienced engineers. In June, the Civil Service Commission authorized increases of $135 to $1075 in annual salaries, formerly $4345 to $7570.

When asked why engineering



Range of starting salaries for engineering graduates has risen consistently since 1949. Averages for the 1956 class are $410 to $435 per month.

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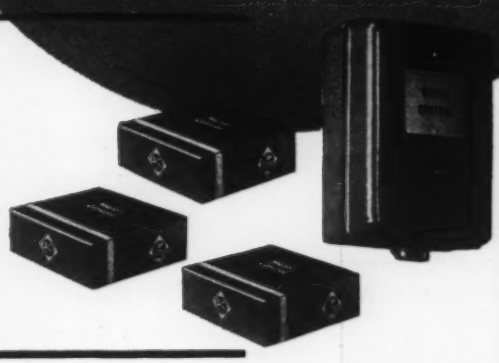
MOTOR CONTROL

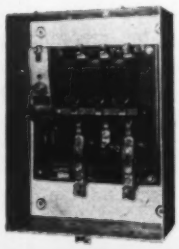
Complete Line



SIZE 0-3 STARTERS

Converta-Kits Permit Easy Modification of Basic Starter

You get MORE . . . more flexibility with Allis-Chalmers control. A screwdriver and the proper *Converta-Kit* are all you need to change a basic Allis-Chalmers size 0-3 starter into the exact unit demanded by your production. *Converta-Kits* are available for push-button, selector switch and electrical interlock modifications. Starter replacement parts—contacts, magnetic coils and overload relays —are also available in packaged kits.



1. Arc across contacts as they start to open.
2. Strong blowout action forces arc to center.
3. Contacts fully open — arc extinguished.

NEW LINE OF SIZE 4-5-6 STARTERS

Quick Quenching Extends Contact and Chute Life

Heart of these starters is a new contactor which uses a revolutionary principle of arc interruption. In centering the arc, increased blowout action and fast quenching result from a combination of thermal convection and magnetic action. Since the arcing time is sharply curtailed, contact and chute life are greatly extended.

HIGH VOLTAGE STARTERS

Complete "Line-to-Load" Control and Protection

Allis-Chalmers Type H starters are built in a wide range of ratings for squirrel-cage, wound-rotor and synchronous motors . . . for full or reduced voltage — reversing or non-reversing — with plugging, dynamic braking and multi-speed features. Built into the starter is the type and degree of protection dictated by the application.

What is your control problem?

As manufacturers of a diversified line of industrial equipment, Allis-Chalmers has solved thousands of control application problems. This specialized experience is yours when you specify Allis-Chalmers control. See your Allis-Chalmers representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

Converta-Kit is an Allis-Chalmers trademark.

A-C ALLIS-CHALMERS

A-4988

ALLIS-CHALMERS

graduates selected the companies they did, placement directors indicated that graduates generally were looking primarily for long-range opportunities and assignments in keeping with their interest; secondarily for immediate compensation. The report from Lehigh is typical. The order of replies from University of Pennsylvania is nearly identical.

Nearly all the schools report that the location of companies has become an increasingly important factor, consistently outranking the starting salary.

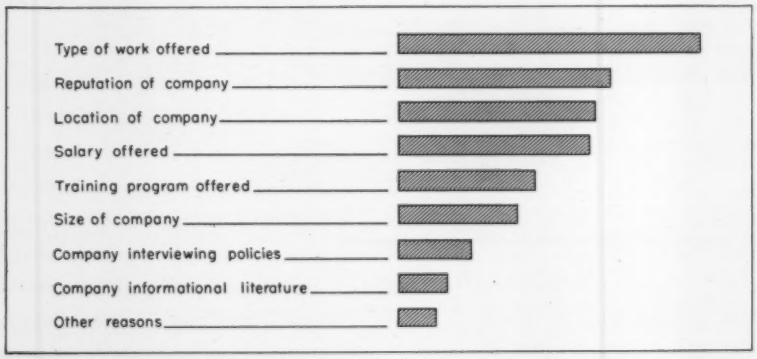
Starting Monthly Salary Distribution: Lehigh Graduates

Quartile	ME	EE	All Eng.	Arts	Bus.	Total
Highest	425–490	440–500	425–500	420–435	400–500	425–500
Second	420–425	420–440	415–425	400–420	375–400	410–425
Third	410–420	405–420	400–415	375–400	350–375	395–410
Lowest	360–410	385–405	315–400	235–375	240–350	235–395
Mean	420	426	418	380	377	392
Increase over '55						
Dollars	43	30	35	26	35	32
Per cent	10.4	7.6	9.1	7.3	10.2	8.6

The same kind of surveys by companies confirm the reports from schools. Illinois Bell has reported that candidates for employment consider opportunity for advancement most important. Interesting work, company training, steady work and location, in that order, all come ahead of starting salary.

The desire for further education or the appreciation of individual treatment may be evident in the Northwestern report that the operation of training programs was most important to its graduates.

Seniors report they have 10 or more interviews and that one-half materialize as job offers. Company recruiters, however, report the other side of the picture. From 6000 interviews, General Motors recruiters expected to recommend one-third for employment. The companies can ill afford to make many mistakes, for each mistake, according to the American Management Association, may cost $10,000 in recruiting and training expenses.



Factors influencing choice of jobs by new engineering graduates from Lehigh are typical of other schools. Location is becoming increasingly important.

MOST POWERFUL SPAR MILL has four independently controlled, 100-hp milling heads. It cuts 1600 cu in., or about 150 lb, of aluminum alloy per minute and can accommodate parts 3 ft wide and 60 ft long. The machine is accurate to 0.001-in. under tracing control. It was built for the Air Force by Farnham Mfg. Div. of Wiesner-Rapp Co. Inc.

Patents Describe New Continuous-Casting Process

DAYTON, O.—Two new patents represent major steps forward in the refinement and improvement of the continuous casting process for steel and nonferrous alloys. The patents are the result of developments at Commonwealth Engineering Co.

Both apply the gas plating process to coat cast metals in a continuous process, in one case, and to make corrosion resistant clad steel in another.

In the first patent, apparatus described uses the hot metal's own heat to effect gas plating. After the metal has issued from a shaping mold and cooled to a solid form, it passes through an insulating sleeve. Here the temperature is reduced to a range from

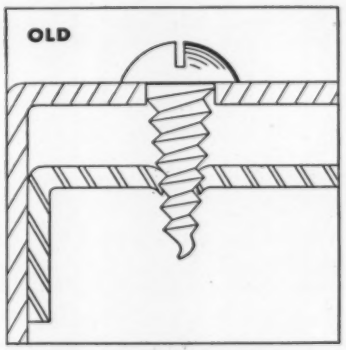
B.F. Goodrich Rivnut

provides shockproof nutplate, saves time and money

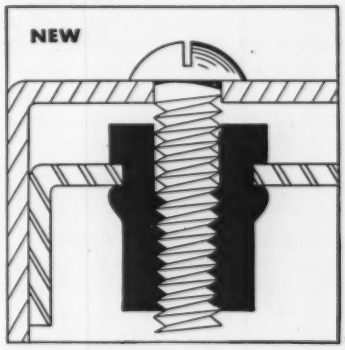
B. F. Goodrich Rivnuts provide accurate, shockproof nutplates in one, quick operation. They eliminate nuts, welding, tapping, clinching. They are particularly suited for blind applications where other methods of fastening are impossible. They give a tight, dependable seal. And save man-hours, too, because one operator can install a Rivnut in seconds.

Just as BFG Rivnuts speeded up output and eliminated assembly and service problems for the Graef Storm Window Co. (SEE PICTURES AT RIGHT), Rivnuts are uniquely successful when used in any thin sheet metal. They are the only method of fastening available that gives 6 clean threads for attachment. They can even be installed *after* enameling.

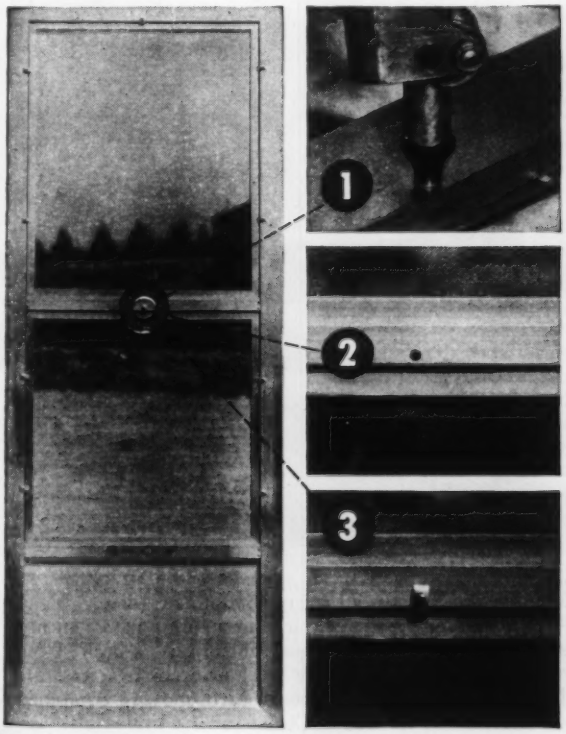
If you're looking for a fastener that can improve your product and cut production time, why not get the help of The B. F. Goodrich Co., Dept. MD-96, Akron, Ohio.



USING SELF-TAPPING SCREWS. To attach insert clips to aluminum storm doors, the Graef Storm Window Co. considered a conventional method, tried self-tapping metal screws. They found that due to the softness of the aluminum, screws pulled out and enlarged the hole. A new hole had to be made or a larger self-tapping screw used. They could foresee service problems. When storm windows were changed by the user, the metal would pull or tear.



USING B. F. GOODRICH RIVNUTS. No assembly problems, no service problems, reports Graef. Rivnuts speed assembly—installing in door stiles takes only seconds. They provide a firm, accurate nutplate that does not loosen with shock or vibration. At least 6 threads are clean for attachment, eliminating any pulling or tearing of metal during assembly or later, when storm windows are changed by the user.



HOW GRAEF SPEEDS ASSEMBLY USING RIVNUTS
(1) Rivnut is inserted in blind aluminum door stile. Heading tool forms bulge inside in one, quick operation. (2) Rivnut fits smoothly, tightly. Six clean threads provide attachment for (3) bolt and retaining clip which holds screen insert. Door slamming, change of inserts will not loosen the nutplate the Rivnut provides.

Send now for FREE RIVNUT Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Department MD-96, Akron, Ohio.

B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads

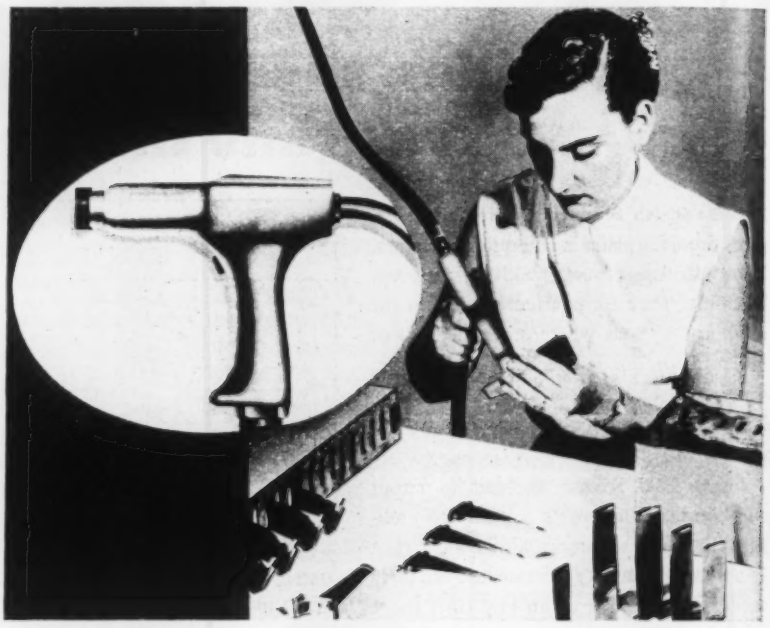
Circle 510 on page 19

300 to 600 F, depending on the type metal being cast and thickness of casting.

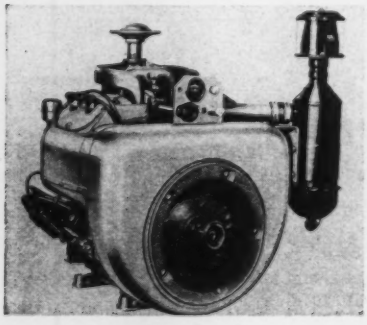
In this temperature range, gas plating is possible. Passing through a plating chamber, heat from the metal is used to volatilize the plating compounds. These are primarily the metal carbonyls but also include nitroxsl compounds, metal hydrides, metal alkyls, and metal halides. Nickel, iron, chromium, molybdenum, cobalt and mixed carbonyls can be deposited.

The second patent applies more particularly to corrosion-resistant clad steel. The process overcomes the disadvantages of deposition of thin coatings on relatively small objects.

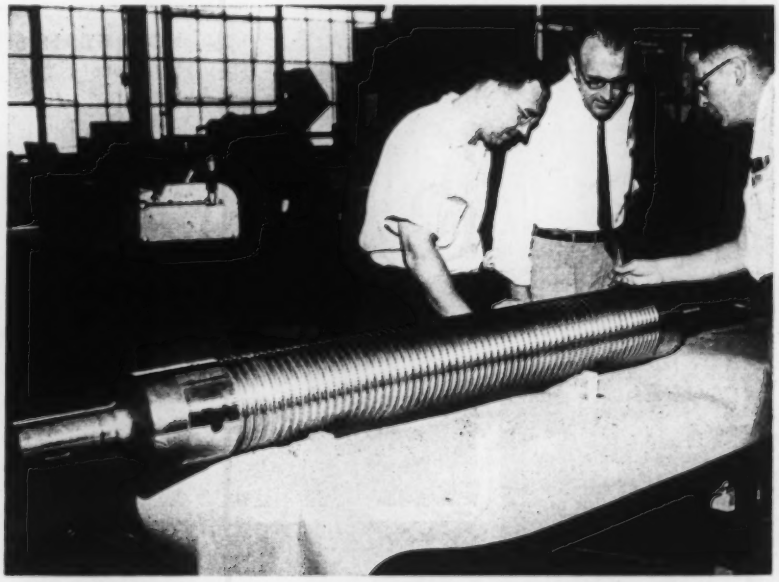
First, a steel billet is cast in the range of 1900 to 2500 F. This temperature is lowered to about 350 to 450 F in a nonoxidizing atmosphere. At the lower temperature, the billet is brought into contact with a gaseous atmosphere containing a corrosion-resistant gaseous metal compound. The compound decomposes, leaving a thick metal coating of about 0.10-in. The plated billet is reheated to the 1300 to 2500 F range and hot worked through a roughing and finishing roller train. This produces a clad steel sheet with a protective metal coating about 0.0005-in. thick.



MANUFACTURERS CAN MAKE THEIR MARK with this new portable unit for permanently reproducing inspectors' symbols, codes and designs on machined, glazed or polished surfaces. Called "Airgrit," the device is available from Jas. H. Mathews & Co., Pittsburgh. It leaves an "etched" impression on the surface of a part by blowing fine abrasive grit through the relieved portions of a rubber mask. Both the depth of marking and the marking time cycle are controlled. Marking may be performed with a gun aimed at any angle to the work. Size of the markings can be ½ to 0.055-in. diam.



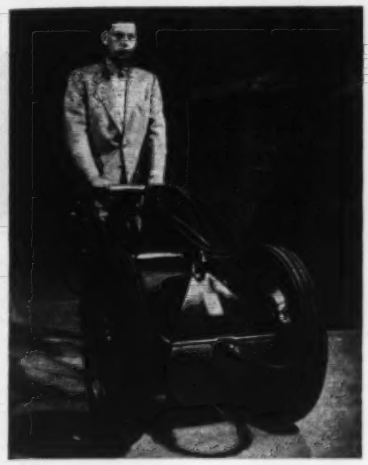
MOST POWERFUL OF ITS SIZE is the claim of Wisconsin Motor Corp. for its new 30-hp model VH4. The four-cylinder, air-cooled, V-type engine operates on kerosene, natural gas or fuel oil of 35 octane rating; has maximum speed of 2800 rpm. It is intended for heavy-duty application in farm and construction equipment, light tractors and materials-handling equipment.



ONE OF THE LARGEST OF ITS KIND, this 79-spline involute type broach has a diameter of 8.040 in. and an overall length of 74 in. It will produce splines in a 4.750-in. long steel workpiece in a single pass. In processing the tool to assure hardness with maximum uniformity, a hole 3½ in. in diameter was bored lengthwise through the steel prior to heat treating. The broach was made for a manufacturer of heavy earth-moving equipment by Continental Tool Works Div. of Ex-Cell-O Corp.

Hot Cart Carries X-Rays To Point of Use

PHILADELPHIA, PA. — A portable isotope radiography machine designed for field work has been developed for the Newport News Shipbuilding and Drydock Co. by the Nuclear Systems Div. of The Budd Co. Named Multitron, the



unit is claimed to be the most powerful of its type developed to date.

The Multitron employs radiation from a 50-curie cobalt-60 source and may be used to detect flaws in atomic reactor shielding, castings, welded joints and fabricated products such as boilers and pressure vessels.

Completely self-contained, the unit requires no power supply and can be wheeled by one man to in-plant locations or taken out for field work. The Multitron can make internal and panoramic X-ray exposures.

Abrasion-Resistant Coating Now Spray-Applied

CHICAGO, ILL.—The new line of oxide coatings, developed by the Norton Co. and known by the trade name Rokide, is being applied to base metals and other materials by means of a specially designed metallizing gun made by the Metallizing Co. of America.

(*Continued on Page 22*)

DRAFTING TRENDS

"Control" is the main factor in the trend to better prints. Nothing is left to chance in Post's exclusive controlled coating process.

Blueprints and diazo prints are getting better every year

In the 1890's, uniform, sharp reproductions were hard to get . . . and for good reason! Manufacturers of sensitized papers took ordinary paper stock and the best paint brush they could buy, then *painted on* emulsions! Color of developed blueprints often varied greatly from one end of the sheet to the other.

Through the years, better blueprint and diazo papers resulted from technological advances in three fields. In the *paper industry*, mills perfected higher quality stock to accept improved emulsions. Improvements in emulsion resulted, in turn, from production of purer *chemicals*. Then, to transform superior emulsion and stock into better sensitized paper, Post designed and built their own *controlled coating* machines. Each machine rigidly controls every phase of blueprint and diazo paper production for absolute uniformity from roll to roll.

"Control" opens new era

Back in the 1890's, paper stock was not uniform . . . coating patterns varied with the skill of the brusher . . . color was pure guesswork. During the past 60 years, production of blueprint and diazo paper left the age of chance and entered an era of scientific control.

Today, sensitized emulsions and coating techniques are rigidly controlled to assure sharp line images, intense color and clear background. Base paper is carefully selected and thoroughly tested for durability, ease of trimming, and ability to take repeated creasing. Even temperature and humidity are held to close tolerances to prevent variations in print quality.

What was considered good paper and reproduction quality just a few years ago now fails to meet minimum standards. At Post laboratories new developments in paper composition, chemical production and reproduction techniques are being translated daily into still better prints.

New brochure on better prints now available

Now is the time to investigate rapid advancements in print quality. If your firm has reproduction equipment to make its own prints, write today for Post's brochure on how to get better, sharper prints through *controlled coating*.

Write to the Reader Service Division, Frederick Post Company, 3652 N. Avondale, Chicago 18, Illinois.

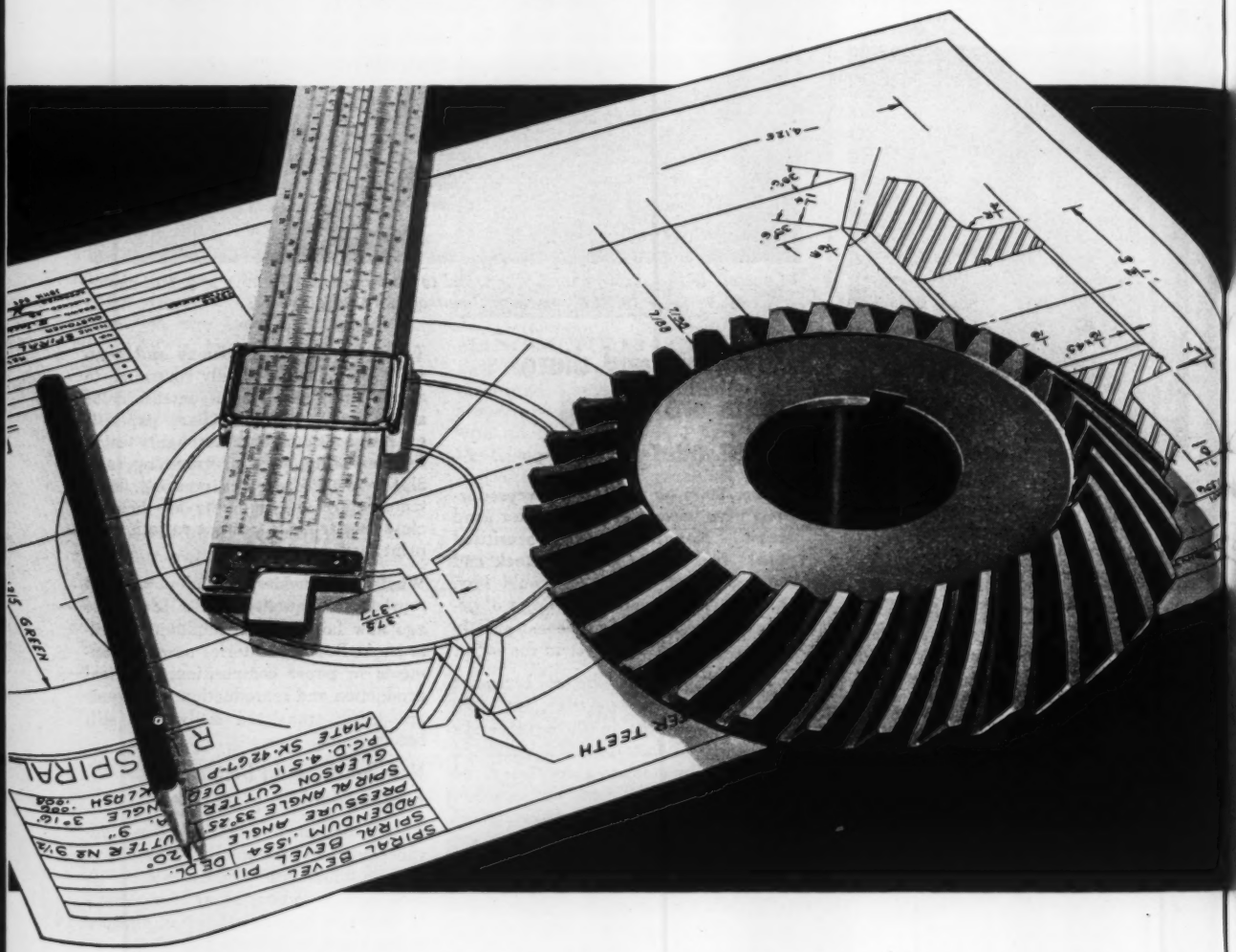
POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

Circle 511 on page 19

"ENGINEERED QUOTATIONS"

When our engineers study our customers' prints, they look for ways to improve gear performance, ways to simplify gear installations, ways to cut gear costs. When they find a way that they consider better they report it to the customer for his consideration. Very often these "engineered quotations" are accepted. Such careful scrutiny of every engineering and manufacturing step by *gear specialists* is one reason why so many manufacturers use Automotive Gear Works as their "gear department". May we submit an "engineered quotation" on your gear requirements?



DOUBLE DIAMOND GEARS

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914 — RICHMOND, INDIANA

SUBSIDIARY OF EATON MANUFACTURING COMPANY

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Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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SEPT. 20, 1956

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When you design for SOCKET SCREWS

. . . you don't need anything else!

Provides more pertinent data than you can find in a Catalog!

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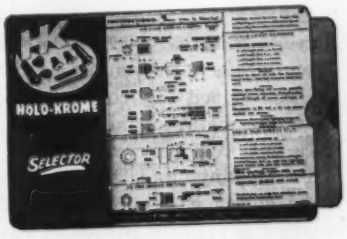
STANDARD LENGTHS • STANDARD POINTS

ALL PERTINENT DIMENSIONAL AND PHYSICAL DATA

In the past two years, thousands of design engineers have written us requesting this H-K Selector. They know the H-K Selector is a valuable tool designed by engineers *for* engineers. When you need information at your fingertips to select the proper size and type of socket screw, you'll find the H-K Selector as handy as your slide rule. *It's yours free for the asking!*



Another Holo-Krome service feature—along with SAME-DAY SERVICE on catalog items, SAME-DAY INQUIRY SERVICE, SPECIALS shipped in 4 weeks or sooner!

HOLO-KROME
Completely Cold Forged
SOCKET SCREWS

THE HOLO-KROME SCREW CORP.
HARTFORD 10, CONN.

Circle 513 on page 19

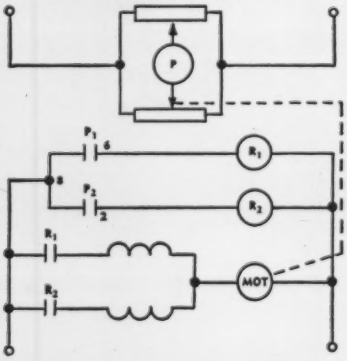
BARBER COLMAN

ultra-sensitive relays

HELPFUL DATA FOR YOUR CIRCUITRY IDEA FILE...

(No. 2 in a series by Barber-Colman Company)

The circuit drawing below indicates just one of the hundreds of ways many manufacturers are utilizing Barber-Colman Micropositioner ultra-sensitive relays to solve complex control problems. Could this be the answer to some of yours, too?



SERVOMECHANISMS APPLICATIONS

Many remote positioning applications can be solved by utilizing the Barber-Colman Micropositioner ultra-sensitive relay either as a null detector or a differential relay.

In the circuit shown above, movement of the transmitting potentiometer introduces an error signal in Micropositioner coil P, which in turn energizes the positioning motor until balance is restored. Secondary relays R_1 and R_2 operated by the Micropositioner handle larger loads. This circuit can also be applied to synchronization . . . or the Micropositioner can be utilized in the output of an electronic servo control.

Among the many applications for this simplified servo control relay are positioning of antenna rotators and tuning condensers . . . aerial camera mounts . . . valves . . . test cell apparatus.

If your projects involve servomechanisms, why not make a test with a Micropositioner designed for circuits similar to that shown above? Write for technical bulletins F7279 and F3961-5.

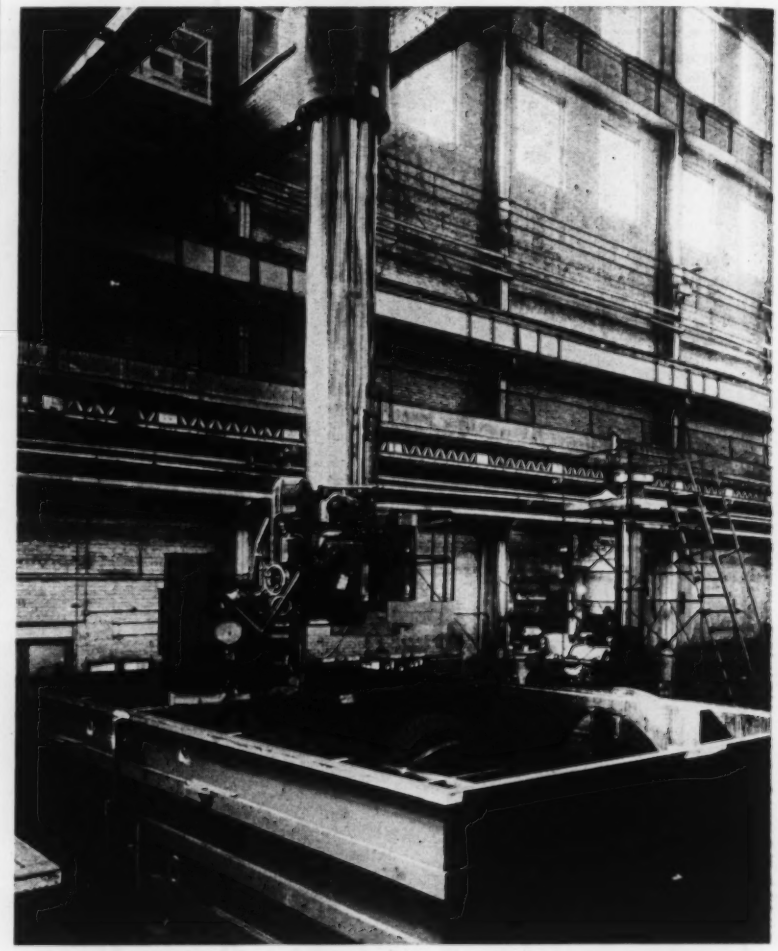
BARBER-COLMAN MICROPOSITIONER POLARIZED DC RELAYS

Various types...plug-in, solder-lug, screw terminal, hermetically sealed. Operate on input powers of 50 to 1,000 microwatts for use in photoelectric circuits, resistance bridge circuits, and electronic plate circuits. Send for data.

Barber-Colman Company

Dept. I, 1473 Rock Street, Rockford, Ill.

Circle 514 on page 19



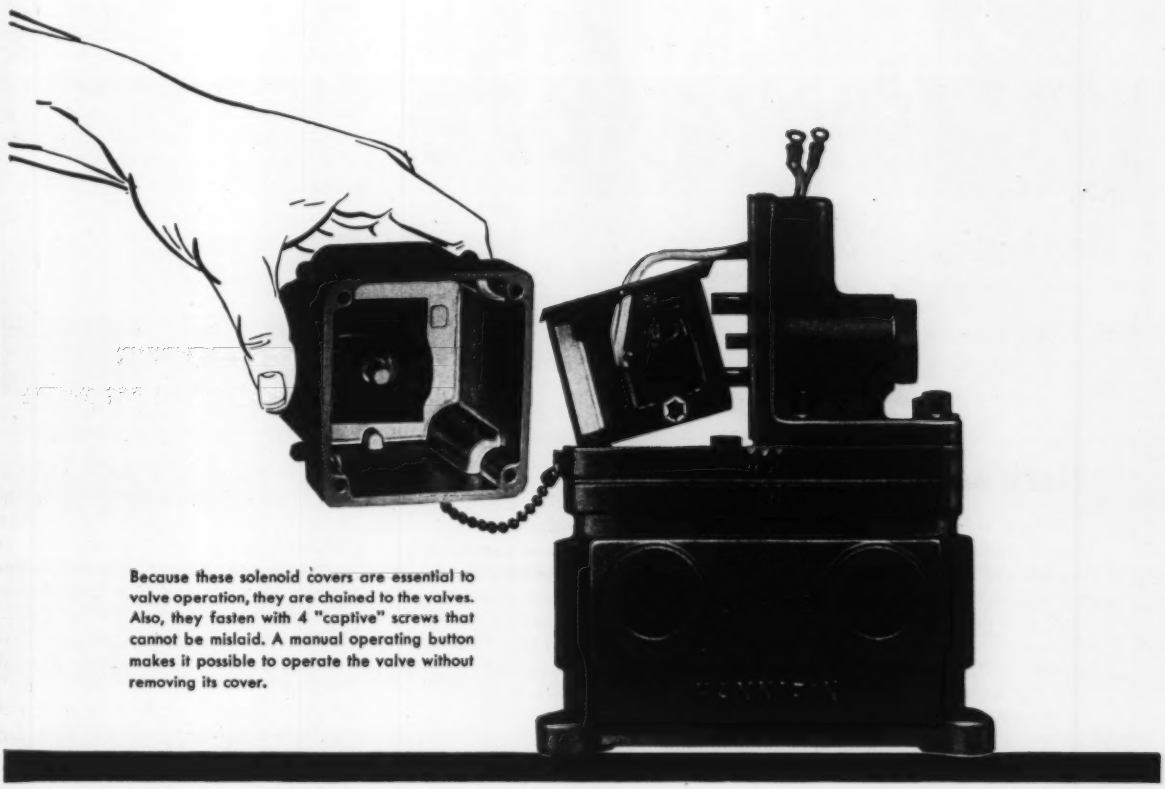
CRANE-MOUNTED RADIAL DRILL PRESS, the first of its kind in this country in size, range of travel and ease of control, is here being used to drill holes in the water box of a 100,000-sq ft condenser at the West Allis Works of Allis-Chalmers. Conceived by Allis-Chalmers engineers, the unit consists of a crane bridge mounted on the lower crane rails in the erection shop, a trolley that runs laterally to the crane movement, a 30-in. diameter column, and a drilling unit. The drilling unit is the head from a conventional 4-ft radial drill press, modified to suit this adaptation. It is able to drill 3-in. holes in mild steel and 4-in. holes in cast iron. Vertical stroke of the machine's column is about 15 ft and trolley travel about 50 ft. Pushbuttons controlling five motions permit positioning the drill fast and accurately.

(*Continued from Page* 15)

The Rokide coatings are proving to be successful in protecting underlying metals from abrasion and excessive heat when used in rockets, jet engines, guided missiles and comparable commercial applications.

Early experiments with these coatings in powder form showed good protection but lacked adherence to the base metals. This led to the development of materials in rod form that could be applied through the metallizing gun.

The new oxyacetylene gun reduces the rod to molten particles at temperatures in excess of 5000 F and projects the molten particles at high velocity by compressed air onto the metal surface. The surface is previously roughened by grit blasting and the resultant bond shows good adherence. The coating is slightly porous in structure and has demonstrated good



Because these solenoid covers are essential to valve operation, they are chained to the valves. Also, they fasten with 4 "captive" screws that cannot be mislaid. A manual operating button makes it possible to operate the valve without removing its cover.

Now! solenoid-controlled air valves that defy improper maintenance ...they won't operate with their covers off!

When a solenoid valve operates without its cover, trouble is not far off. Dirt, oil, cutting fluid, chips are sure sooner or later to jam the solenoid, and the valve will fail to shift.

That can't happen with these new Hannifin valves!

The solenoids are held in place by their covers and won't operate the valves unless the dust-tight, splashproof covers are firmly tightened.

These new valves, which conform to the latest J.I.C. recommendations, are part of the complete "P-M" Pilot-Master line. New heads with these new solenoid covers are offered on 2-way, 3-way and 4-way Pilot-Master Valves (air-operated). The smaller, direct-operated 3-way and 4-way valves in the "P-M" line have been redesigned to use the same new covers. This added feature is just another reason why it pays to standardize on Hannifin air control valves.

AIR CONTROL

HANNIFIN

VALVES

Complete information on all Hannifin Air Control Valves is in this catalog. It belongs in your files. Write for your copy. Hannifin Corporation, 515 S. Wolf Road, Des Plaines, Illinois.

Circle 515 on page 19

Introducing

Another NICKELOID First!

Here's what Bakekote is

Bakekote is the Nickeloid family trademark for a revolutionary new *baked synthetic* protective coating for Nickeloid pre-finished metals, in copper and brass finishes. It contains one of the newest thermosetting resins with film properties far superior to regular lacquer and most other synthetics on the market: maximum gloss, hardness, adhesion, flexibility, chemical resistance, abrasion resistance. The clear Bakekote film is applied to Nickeloid Metals by spray or pressure, then *baked and cured* (not just air-dried) with intense heat. *There is no comparable product on the market today.*

RIGIDLY TESTED and PROVEN

Flexibility | Excellent Adherence | No Peeling

A stamped pan, severely drawn shows no evidence of lifting or cracking.

A canister lid, stamped without a draw ring, has perfect adherence even on the wrinkled flange.

Seamed canister bodies are formed with no lifting or peeling of the Bakekote film.

Greater Salt Spray Resistance

Actual photo of results from 48 hr. salt spray test on pre-plated Copper Steel shows Bakekote (right) provides 80% to 90% better resistance than regular lacquer finish (left).

where you can use Bakekote

A tough, adherent, elastic film, Bakekote coated metal can be drawn, press formed, stamped, roll formed and seamed with no fear that the coating will peel, crack or flake. It's the ideal *protected* copper or brass finish for door hardware, switch plates, knob inlays, light fixtures, bezel plates, housewares.

Write for Details

NICKELOID METALS SINCE 1898

AMERICAN NICKELOID COMPANY

PERU 8, ILLINOIS

Circle 516 on page 19

flexibility.

One 24-in. standard rod of aluminum oxide (Rokide A), ⅛-in. in diameter, will cover approximately 20 or more sq in., 0.010-in. thick, in 6 minutes. Experiments are continuing with larger sized rods which will afford about double that rate of application.

THERMAL CATALYTIC DUCT has been introduced recently by Instrumentation Associates. The duct employs a flexible metal hose in which a catalytic reaction occurs between air and hydrocarbon vapors forced through the duct by a pump. Controls enable heat output continuously or intermittently, with periodic addition of liquid fuel. Duct cross-section can be round, flat or other shapes and the duct can be wrapped, bent or twisted on objects to be heated.

High-Frequency Vibrator Is Hydraulically Powered

EL SEGUNDO, CALIF.—A new design concept which uses electronically actuated hydraulic power amplification will be applied in a new vibration testing system rated at 20,000 lb block force.

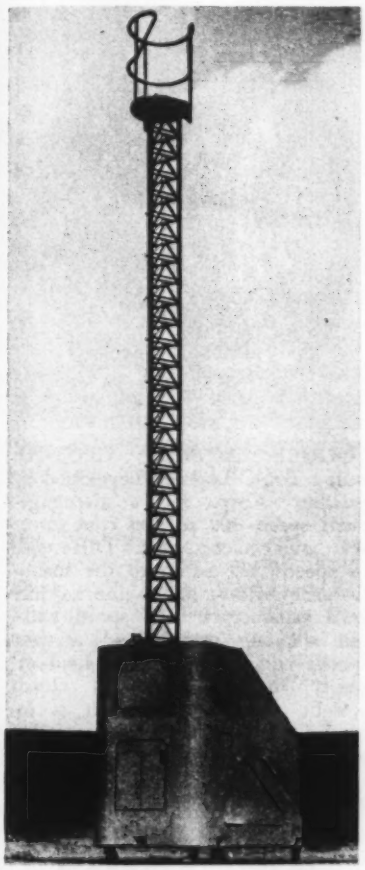
Known as the Hydrashaker, the equipment will be produced and marketed by Wyle Mfg. Corp., under license from Northrop Aircraft Inc. The system has been field-tested in a prototype constructed by Northrop for vibration evaluation tests on its *Snark* guided missile.

The new equipment will produce accelerations up to 100 *g* with 0.2-in. total displacement. A useful frequency range of from 5 to 2000 cps is expected.

Only 15 per cent of available force is expended by the Hydrashaker for driving its 30-lb moving assembly.

Advantages claimed for the new vibrator are the elimination of the magnetic field inherent to electrodynamic equipment and accurate control of reaction forces.

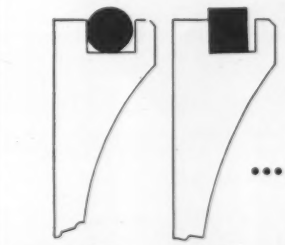
The vibrator will be powered by a 75-hp, motor-driven, 3C00 psi hydraulic pump. A complete electronic exciter console with monitor-



50-FOOT MAST sprouts from its 7½-foot high enclosure to carry such passengers as workmen and cameramen above the ground. The retractile mast consists mainly of a three-sided, articulated chain that winds flat onto a drum when not in use. An electric motor, operating through a gear reduction unit, unrolls the links from the drum. As the links travel through curved guides, the two outer sections swing inward and join together to form a rigid, triangular mast. Speed of ascension is 15 fpm. The unit is made in England by Mitchell Engineering Ltd.

Why ACADIA LATHE-CUT SYNTHETIC RUBBER SEALS

can save you money in *STATIC* or *MOVING* seal applications



....This seal will save you money with no performance sacrifice. Minimum tooling cost, no molds, no costly delays. Can be made up to 25" I.D.

Acadia Synthetic Rubber Parts are the highest quality components, processed for oil resistance, good aging properties, resistance to heat. They can be furnished in any dimension or special compound you desire to precision tolerances. They are another example of Acadia's ability to SAVE YOU MORE . . SERVE YOU BETTER.

There's an Acadia Sales engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA *Synthetic* PRODUCTS

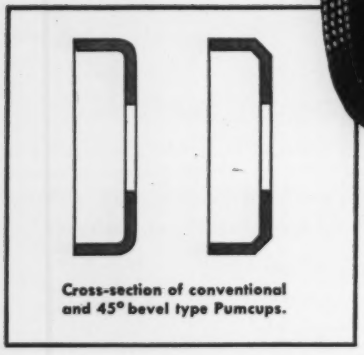
DIVISION OF WESTERN FELT WORKS
4021-4139 West Ogden Avenue, Chicago 23, Illinois

Branch Offices — LOOK in the 'Yellow Pages' — in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

Circle 517 on page 19

2-way gain with Pumcups



Cross-section of conventional and 45° bevel type Pumcups.

Darcova Pumcups are available in various types and textures, in a complete range of sizes, to provide unequalled efficiency and long life in reciprocating pumps, air or hydraulic mechanisms.

★ prolonged high efficiency
★ less maintenance

TODAY hundreds of companies using hydraulic controls, air cylinders or reciprocating pumps are *standardizing* on Darcova Pumcups for piston packing, because they eliminate fluid slippage, costly down-time and maintenance.

Darcova Pumcups make the *most* of the cup packing principle. And, they are made in a complete range of sizes, types and texture-engineered compositions for various pressure-temperature-fluid conditions. Pumcups hold peak efficiency for the life of the cups and outlast other packing as much as 3 to 1.

Why not check these claims right in your own plant? Meanwhile get *all* the facts. Just send for Pumcup Bulletin No. 5503.

DARLING VALVE & MANUFACTURING CO.
Williamsport 30, Pa.

DARCOVA — THE ORIGINAL COMPOSITION CUP

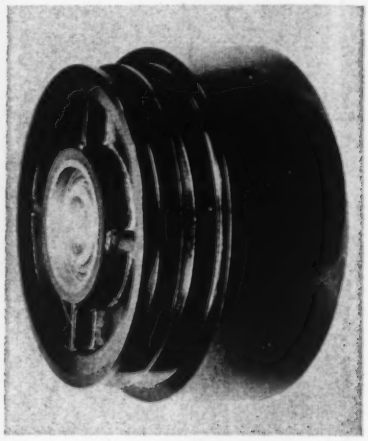
TRADE MARK PUMCUPS

Circle 518 on page 19

News Roundup

ing instruments will be included.

A system for programming variable frequencies, with associated circuitry, will be available to preset and maintain acceleration loads. Provisions for performance of mixed frequency and noise vibration analysis is under development.



TOGGLE ACTION CLUTCH, called Tog-O-Loc and developed by Salisbury Corp., has a disengagement speed 400 to 500 rpm lower than engagement speed. Difference in speeds, according to the manufacturer, allows an engine to idle at a satisfactory high speed without slipping under load at low speeds and allows greater load capacity in proportion to clutch weight. Tog-O-Loc clutch is intended for 10 to 50 hp gasoline and diesel engines.

Meetings

AND EXPOSITIONS

Oct. 3-5—

Standards Engineers Society. Fifth Annual Meeting to be held at Hotel Willard, Washington, D. C. Further information can be obtained from society headquarters, P. O. Box 281, Camden 1, N. J.

Oct. 4-5—

Magnesium Association. Annual Meeting to be held at the Drake

Hotel, Chicago. Additional information is available from association headquarters, 122 E. 42nd St., New York 17, N. Y.

Oct. 8-10—

American Society of Mechanical Engineers. ASME-ASLE Third Lubrication Conference to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Oct. 8-12—

National Metal Congress and Exposition to be held at the Public Auditorium, Cleveland. Participants in the scientific sessions will be the American Society for Metals; the American Welding Society; the Institute of Metals Div. of the American Institute of Mining, Metallurgical and Petroleum Engineers; and the Society for Non-Destructive Testing. Additional information can be obtained from show headquarters, 7301 Euclid Ave., Cleveland 3, O.

Oct. 10-12—

Society of Automotive Engineers. National Transportation Meeting to be held at Hotel New Yorker, New York. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Oct. 16-18—

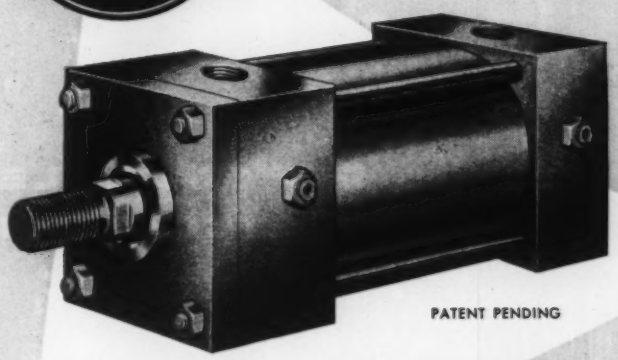
Conference on Magnetism and Magnetic Materials to be held at Hotel Statler, Boston. Sponsored by the American Institute of Electrical Engineers in co-operation with the American Physical Society, the American Institute of Mining & Metallurgical Engineers and the Institute of Radio Engineers. Further information is available from T. O. Paine, Measurements Laboratory, General Electric Co., West Lynn, Mass.

Oct. 18-19—

National Conference on Industrial Hydraulics. Twelfth Annual Meeting to be held at the Sherman Hotel, Chicago, sponsored by Il-

FOR AUTOMATION

S-P CYLINDERS



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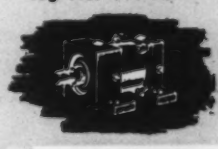
top performance-longest life

All S-P cylinders are engineered throughout for high speed, efficient operation. Piston rods are heat treated and hard chrome plated to resist scoring. Bronze cartridges with extra long bearing surfaces are easily removable for quick servicing of rod seals and wipers. End plates are rolled steel. All S-P cylinders are built to JIC standards.

S-P STANDARD AIR CYLINDERS have brass tubes to eliminate corrosion. Cushions float on O-rings for maximum cushioning. Eleven bore sizes, 1½" — 14". 21 mounting types. Readily modified for oil or water. Send for Catalog No. 110.

S-P HEAVY DUTY AIR CYLINDERS for automation and other severe applications. Double porting for extreme high speeds. Heavy wall seamless steel tube. Nine bore sizes, 1½" — 8". Five mounting types. Approved and used by two major automobile manufacturers. Send for Catalog No. 109-A.



S-P HIGH PRESSURE HYDRAULIC CYLINDERS have seamless steel tube. Special locking mechanism eliminates tie rods. Designed for 2,000 psi. Eleven models in 11 sizes. Send for Catalog No. 104.

Step up production with S-P cylinders. Representatives in principal cities. Prompt deliveries. Order catalog by number shown above. The S-P Manufacturing Corporation, 30201 Aurora Rd., Solon, Ohio. *In greater Cleveland.*

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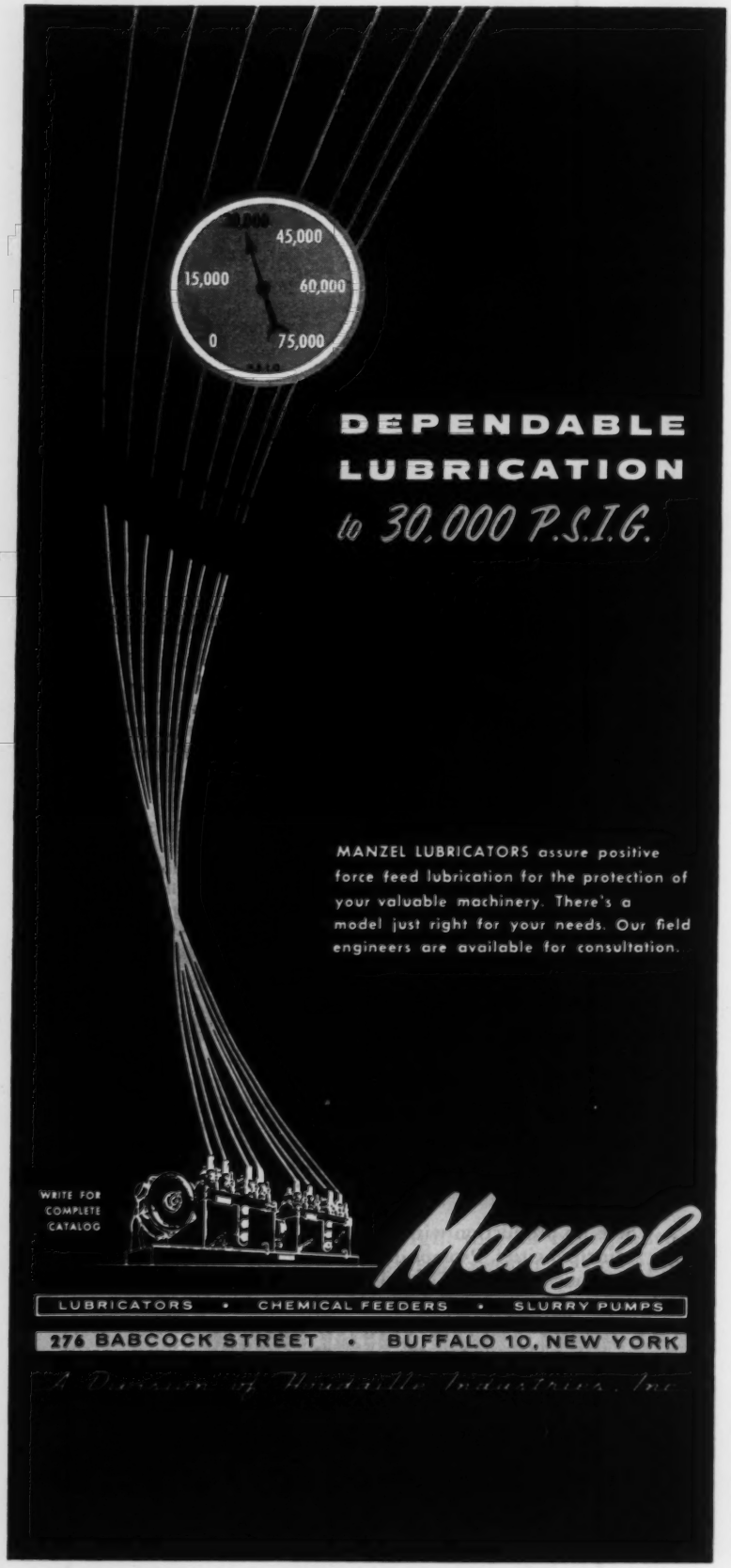
Circle 519 on page 19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Circle 520 on page 19

News Roundup

linois Institute of Technology. Further information can be obtained from Joseph J. Kowal, Conference Secretary, Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Oct. 22-24—

Purdue University. First Conference on Manufacturing Automation cosponsored by *Automation* Magazine. Additional information may be obtained from Editor, *Automation,* Penton Building, Cleveland 13, Ohio.

Oct. 22-26—

National Industrial Exposition and Management Conferences to be held at the Artillery Armory, Detroit. Additional information can be obtained from A. F. Denham, Exposition Director, 927 Book Bldg., Detroit 26, Mich.

Oct. 24-25—

American Society of Mechanical Engineers. ASME - AIME Joint Fuels Conference to be held at Sheraton Park Hotel, Washington, D. C. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Oct. 28-31—

American Gear Manufacturers Association. Semiannual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information can be obtained from association headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 30-Nov. 1—

National Fluid Power Association. Fall Meeting to be held at the Hotel Cleveland, Cleveland. Further information can be obtained from association headquarters, 1618 Orrington Ave., Evanston, Ill.

Oct. 31-Nov. 2—

Gray Iron Founders Society Inc. Annual Meeting to be held at The Homestead, Hot Springs, Va. Additional information is available from society headquarters, 930 National City — E. Sixth Bldg.,

Cleveland 14, O.

Oct. 31-Nov. 2—

Society for Experimental Stress Analysis. Annual Meeting and Exhibit to be held at the Deshler-Hilton Hotel, Columbus, O. Further information can be obtained from society headquarters, P. O. Box 168, Cambridge 39, Mass.

Nov. 1-2—

Society of Automotive Engineers Inc. National Diesel Engine Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Nov. 2-3—

Sixth Annual Tool Engineering Conference to be held at Illinois Institute of Technology, Chicago. Conference is sponsored by IIT, Northwestern and Illinois universities and the Illinois chapters of the American Society of Tool Engineers. Further information can be obtained from Prof. Samuel E. Rusinoff, Mechanical Engineering Dept., Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Nov. 7-9—

Steel Founders' Society of America. Technical and Operating Conference to be held at the Carter Hotel, Cleveland. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

Nov. 8-9—

Society of Automotive Engineers Inc. National Fuels and Lubricants Meeting to be held at the Mayo Hotel, Tulsa, Okla. More information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Nov. 12-16—

National E'ectrical Manufacturers Association. Annual Meeting to be held at the Traymore Hotel, Atlantic City, N. J. Further information is available from association headquarters, 155 E. 44th St., New York 17, N. Y.

are you running behind in the vicious race for qualified research and production men?

FOR HIRE experienced technicians with qualifications you want

The critical shortage of experienced physicists, engineers and production craftsmen needn't curtail your output—reduce your profits. The Mechanical Division of General Mills has trained men and specialized machines ready today to handle your design requirements and production of

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MECHANICAL DIVISION OF General Mills

Circle 521 on page 19

ONE OF THE GARLOCK 2,000

Chart shows loss of thickness after alternating wet and dry exposure tests. Garlock 662 returns to within 1% of original thickness. No. 662, made from a cork paper base impregnated with a synthetic rubber, is dimensionally more stable than (A) beater process sheet with synthetic rubber binder, (B and C) sheets saturated with glue-glycerine binder.

GARLOCK 662 GASKET MATERIAL does not shrink or change shape

Here's convincing proof that gaskets of Garlock 662 can stand varying climatic conditions without drying, shrinking, or hardening. The gaskets illustrated were subjected to a 24 hour alternating wet and dry test for weeks, then conditioned at room temperature. As the photo and chart at right show, 662 gaskets returned to their original shape and to within 1% of their original thickness. Competitive types hardened, twisted, and shrank as much as 8%. No wonder so many companies are specifying 662 for use against gasoline, water, and oil at temperatures up to 300°F. It is approved by Underwriters' Laboratories, Inc. for use against hazardous liquids.

And longer-lasting 662 Gasket material is only one of "the Garlock 2,000" . . . two thousand styles of gaskets, packings, and seals to meet all your needs. It's the only complete line. It's one reason you get unbiased recommendations from your Garlock representative. Call him today or write for Bulletin AD-146.

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For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.*

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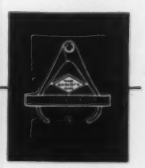


Circle 522 on page 19

MEN

OF MACHINES

Kenith G. Strunk has been appointed administrative director of engineering of Breeze Corporations Inc., Union, N. J. He will be in charge of the entire engineering

Kenith G. Strunk

department, including research, development, drafting and product engineering. Mr. Strunk formerly was president of the engineering consultant firm, Processes Research Inc. From 1934 to 1952 he was a member of the Breeze engineering staff.

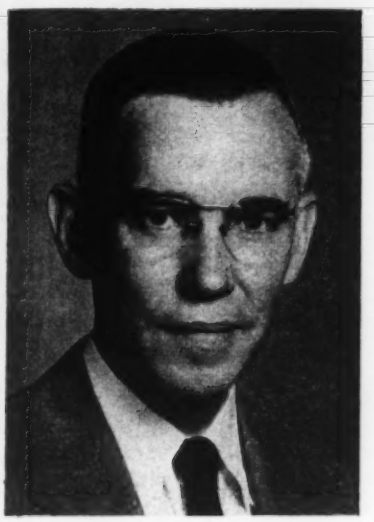
Seneca Falls Machine Co., Seneca Falls, N. Y. recently appointed **V. L. Percy** chief engineer.

Fred J. Fleischauer has been appointed chief design engineer of the Special Machinery Div. of the Teller Co., Butler, Pa. Mr. Fleischauer has gained experience in machine tool and product research and development through his previous affiliations with Rockwell Mfg. Co., Mellon Institute, H. H. Robertson Co. and the Dravo Corp.

Announcement was made recently of the promotion of **James J. Ward** to assistant division manager and the appointment of

Charles A. Kerner as chief engineer of Northrop Aircraft's Anaheim, Calif. division. Mr. Ward has served as chief of quality control and was production manager of the division for one year prior to his current appointment. Mr. Kerner has been associated with Northrop for more than ten years in design and engineering administration.

J. Donald Judge has been named director of research and engineering by the Hamilton Foundry & Machine Co., Hamilton, O. Mr. Judge was associated with the company on a part-time basis while



J. Donald Judge

he was a high-school student and a University of Cincinnati mechanical engineering student. He joined the plant engineering department in 1924 and advanced to the position of chief engineer before receiving his present appointment.

The Instrument Div. of Sterling Precision Corp. has appointed **Sol Levine** chief engineer with headquarters in Port Washington, N. Y. For the last ten years, Mr. Levine has been chief engineer of Edo Corp.

Vickers Inc., Detroit, recently announced the appointment of two departmental chief engineers. **Paul C. Mortenson,** chief engineer for ground mobile products, will be re-

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Circle 523 on page 19

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Problems like configuration, alloy selection, tolerances, surface finish and inspection standards affect production cost and performance. Choose wisely . . . Choose ARWOOD for design assistance and production efficiency.

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"PIONEERS IN INVESTMENT CASTING"

Circle 524 on page 19

Men of Machines

sponsible for development, design and test operations of three separate product line subgroups. **Frank L. Moncher,** chief engineer for airborne products, will be responsible for design, development and test of aircraft type oil-hydraulic pumps and motors as well as complete airborne hydraulic systems.

Appointment of **Domenic A. DiTirro** as manager of research and development has been announced by Valvair Corp., Akron, O. Mr. DiTirro will direct new product design, development and testing and

Domenic A. DiTirro

will also supervise the activities of the company's newly established research and development department. Prior to joining Valvair, he was research and development manager of Ross Operating Valve Co.

William Wilson has been appointed to the newly created position of director of research and development at A. Finkl & Sons Co., Chicago.

National Vulcanized Fibre Co., Wilmington, Del., has appointed **Hjalmer Lundquist** as an engineering consultant. Mr. Lundquist, formerly chief design and tool engineer, recently retired from full service. He has been a member of the company's engineering staff since 1928.

Men of Machines

Georgo H. Brodio has been appointed director of engineering by Kellogg Switchboard & Supply Co., Chicago, a division of International Telephone & Telegraph Corp.

Schutte and Koerting Co., Cornwells Heights, Pa., has announced the appointment of **LeRoy S. Harris** as manager of its recently expanded Research and Development Dept. Mr. Harris was an assistant professor in the Engineering School of Villanova University. He was previously associated with Radio Corp. of America, Bell Aircraft Corp., Baldwin-Lima-Hamilton Corp. and the U. S. Naval Boiler and Turbine Laboratories.

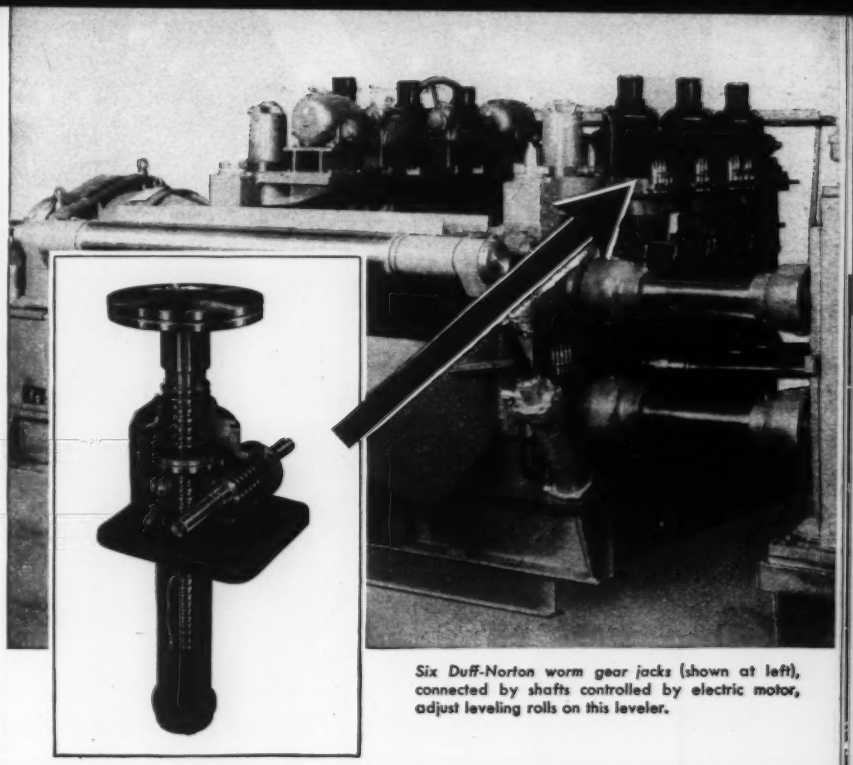
Philip P. Anderson joined Carrier Corp., Syracuse, N. Y., as director of development in adsorption refrigeration for the firm's central research and development division. Dr. Anderson was formerly director of advanced engineering at Servel Inc.

A nuclear specialist, **Fred Grisak,** has joined the engineering department of Temco Aircraft Corp., Dallas, Tex. Since 1952 Mr. Grisak has been associated with the nuclear program at Convair, where he was in charge of preliminary design of the atomic reactor which that company is testing aboard a B-36.

Harry F. Barr has been named chief engineer of the Chevrolet Motor Div. of General Motors Corp. **E. N. Cole** was made general manager, and **E. J. Premo** was appointed executive assistant chief engineer.

Chicago Aerial Industries, Melrose Park, Ill., has appointed **Joseph A. Mathews** manager of the Potentiometer Div. He was formerly chief engineer for the Central Electric Co.

Robert S. Goodyear has been named president of Fenwal Electronics Inc., Framingham, Mass. Mr. Goodyear was vice president and chief engineer of Victory Engineering Corp.



Six Duff-Norton worm gear jacks (shown at left), connected by shafts controlled by electric motor, adjust leveling rolls on this leveler.

Here's a device every machinery designer should know about

It's the Duff-Norton worm gear jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion; applying pressure; resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 45:1; turn of worm for each 1 inch raise, 10 to 180; available in either Acme or square threads. For protection against foreign matter certain models of these jacks can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting — raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses — adjusting electrodes — overhead crane servicing.

Duff-Norton worm gear jacks are made in 6 standard sizes. Write for booklet!

Duff-Norton Company

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Please send immediately a free copy of your new Worm Gear Jack Brochure.

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Circle 525 on page 19

Motor and Control—
standard ratings now
available for immediate delivery
from warehouses coast-to-coast!

TOMORROW:

A standard motor that can survive infinite heat

The new Life-Line A is another step closer

Westinghouse is working on tomorrow's motor today. Investigating new materials—testing existing motor designs.

No standard motor today can survive the ultimate test shown here. But we do know that the new Life-Line® "A" can operate under higher temperatures than ever before. It has stronger insulation and better bearing protection than any other motor on the market. It's industry's closest approach to a standard motor that is absolutely heatproof.

Your Westinghouse sales engineer can show you many additional reasons why the Life-Line "A" is industry's most advanced and preferred motor. Call him today.

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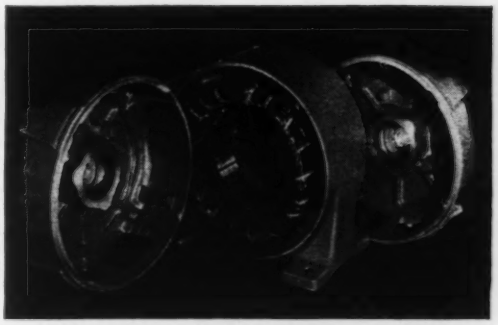
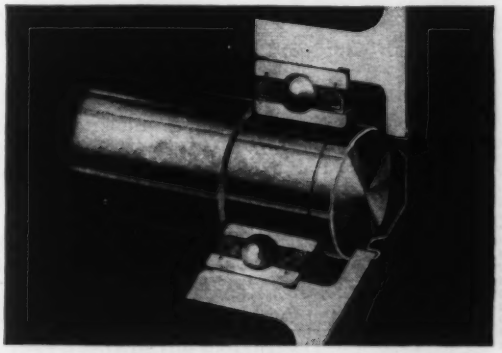


New fortified insulation includes exclusive Bondar, Bondite and Mylar*—three good reasons why the Life-Line "A" is so resistant to heat or any other motor contamination.

*DuPont Registered Trade-Mark



Two outer seals of new 4-way sealed bearing act as flingers and literally throw off damaging contaminations. Inner seals, attached to outer bearing race, are stationary and form a positive labyrinth.

WATCH WESTINGHOUSE!

WHERE BIG THINGS ARE HAPPENING TODAY!

Circle 526 on page 19

Get this Catalog!

For help in fluid line system design . . .

Aeroquip's new 64-page industrial catalog is packed with product information on twenty-six types of high, medium and low pressure hose with reusable fittings, plus adapters and couplings.

You'll find 18 pages of valuable fluid line data to help you in the planning, engineering and installation of fluid line systems on all kinds of industrial equipment.

Aeroquip also offers separate catalogs giving complete information on Aircraft and Marine Hose Lines and Couplings. Fill in and mail the coupon below for your copies.

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Circle 527 on page 19

Circle 528 on page 19→

Alcoa's Up-to-Dater on Screw Machine Products

Four factual pages of news on aluminum screw machine products plus refresher information on alloys, finishes and design tips—all compiled for the eager young men of today, who will run things tomorrow.

Eager young men of today . . .

Fundamentals on the Economics of Aluminum

The great strides made by aluminum screw machine products in recent years have been due to many things . . . many of them based on aluminum's performance, many of them on economic factors. FOR EXAMPLE . . .

It gives the designer a way to save weight. When finished products have to be made lighter in overall weight, designers can save important pounds by using aluminum . . . weighing only a third as much as steel or brass. It provides a means of heavying-up certain components without adding to total weight. Weight saved at one point with aluminum can be shifted to other points where weight is needed.

It helps designers lick inertia problems without sacrificing strength or performance. Spectacular examples of this are found in calculators, business machines, ordnance, projectors, servomechanisms.

It gives designers a way to improve performance while lowering costs. You get three times as many parts per pound of aluminum screw machine stock as you do from brass or steel. And aluminum costs less per pound than brass. Per piece, or by the pound, you can save a bundle.

It gives designers a tool for speeding production while lowering costs. Aluminum is remarkable for its superb machinability. A free-machining metal, it is machined as well or better than the leaded brasses. A large percentage of the time, aluminum is machined as fast as the machine will run.

It frees the designer from corrosion restrictions. With aluminum, designers no longer need to worry about rusting. The initially fine appearance does not deteriorate. They can eliminate many costly features designed to protect critical machined parts from weather or corrosive operating conditions (plating, protective housings and painting). Check the way aluminum screw machine products have taken over the outboard motor and photographic fields!

It gives the designer maximum latitude in finishing specifications. The very nature of screw machine operations gives most metals a good surface finish. But, unlike some other metals, aluminum retains the surface finishes generated by machining. No special precautions are needed to preserve them. And that's just the beginning. You can give aluminum any surface finish you want . . . from a finish so perfect it's used for reflectors, to one rough enough to diffuse light. You can apply a jewel-hard anodic coating that makes the highest surface finish impervious to attack. You can incorporate any color in this anodic coating . . . to get a colored finish that's part of the metal itself.

It provides maximum design freedom. Because aluminum is so workable, so easy to machine . . . finish . . . color, it puts fewer restrictions on the

Advertisement

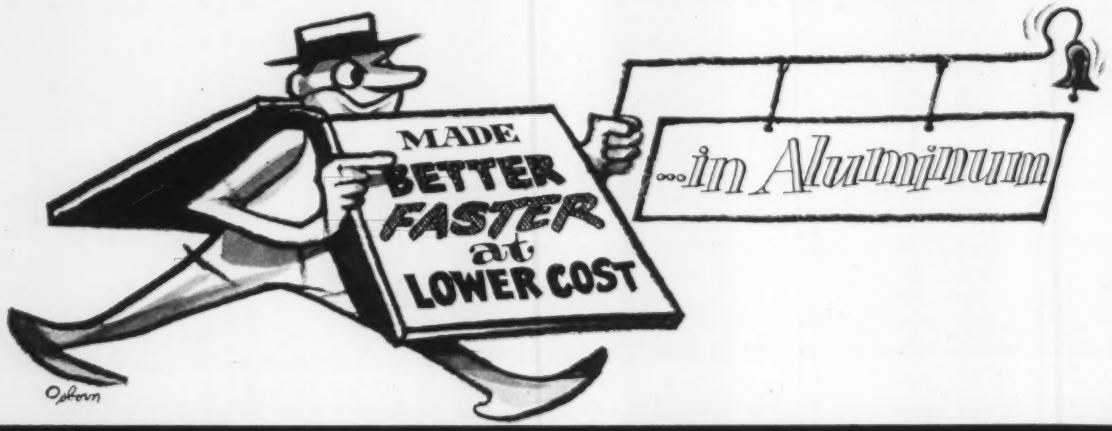
Alcoa's Up-to-Dater on Screw Machine Products (continued)

designer. His designs become less vulnerable to shortages in critical materials. His specifications put a lighter burden on tight schedules. His choice of aluminum makes sense when material costs are considered. His faith in aluminum is justified by its performance in the finished product.

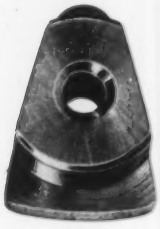
In case you haven't guessed . . .

All these parts shown at the lower left were made by Alcoa at a marvelous new screw machine plant at Lancaster, Pa. They represent the kind of work which is commonplace at Alcoa.

Our Lancaster plant is probably the biggest



Made in brass, the 2-inch ferrule for modern furniture weighed .3 pound and cost 27 cents. Redesigned as an aluminum screw machine part and anodized with a brass color, it weighed only .1 pound and cost only 20 cents.



This is a special nut for a pressure cooker. It would have cost a great deal of money if the triangular shape had been obtained by machining. To avoid this expense, it started as a triangular aluminum extrusion and was turned to two diameters, followed by drilling, tapping, reaming, counterboring and cutoff.

This hydraulic fitting needed aluminum's light weight and the great strength obtained by forging. It was centered, drilled, faced, counterbored, tapped, reamed and recessed in three turret lathe operations. Close tolerances and fine internal finishes were vital.

This machined and knurled pin is an insert for a molded plastic assembly used in electronic equipment. Aluminum was a natural for this pin, since its coefficient of expansion is similar to that of plastic. Aluminum's excellent electrical conductivity was also a factor.

This hearing-aid cap, with a shell thinner than paper, is notable for its close tolerances and delicate anodic coloring. Screw machine operations included drilling, counterboring, facing, forming and cutoff. These were followed by deburring, buffing and anodizing. It has no tool marks, and walls are confined to a thickness of 0.005 to 0.008 at a critical location.

aluminum screw machine plant in existence . . . equipped and staffed to handle any job from machining to light assembly . . . in quantities from a few hundred to millions.

We have hand screw machines for the short-run jobs and a turret lathe department for bigger ones. There are single-spindle machines to make short work of secondary turning, forming and drilling operations.

For the really big production runs, we have an array of multiple-spindle equipment for high-speed operations on stock ranging up to a diameter of 3½ inches.

There's a fully equipped press department with capacities up to 75 tons. We can heat treat, machine, bore, counterbore, tap, grind, buff, burnish, color. We can provide light assembly.

And our finishing department is the last word in completeness . . . with everything needed for polishing to a high luster to adding a rock-hard anodic coating in a variety of colors.

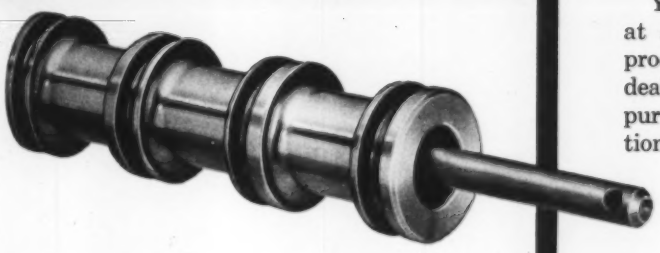
To achieve those neat little production economies that rate so high with our customers, we have the right equipment all under one roof for high-speed upsetting operations and threading . . . a roomful of cold-headers . . . a whole battery of thread rollers.

This plant offers designers, and those who produce or buy to their designs, something unique in the aluminum screw machine business . . . a single responsibility for everything needed for the job.

The Importance of Single Responsibility

Every operation required to produce aluminum screw machine parts is centralized under a single authority at Alcoa . . . from making the alloy to the most complex finishing operations. Moreover, Alcoa's tremendous knowledge of aluminum and aluminum fabrication makes possible every short cut, every way to trim costs, every trick in the book for improving performance.

You, as a designer, can call upon this knowledge at any stage from specifying alloys to detailing production methods. While much of the value of dealing with Alcoa is more apparent from the purchasing viewpoint, your designs and specifications have a direct bearing on both purchasing and actual fabrication. From that standpoint, Alcoa's Lancaster plant becomes the designer's right arm.



This spindle valve looks like a costly piece of machining. And it would have been if some smart tricks with aluminum hadn't been employed. The designer broke the part down into two easily machined sections anchored by a small machined pin. The parts were given an anodic coating and then assembled.

This shape could have been duplicated in most any metal. Its characteristics could not. Designed as a radiator for an electronic component, it was extruded from an Alcoa® Alloy, then cut, deburred. Inner diameter was reamed to .0009. Final operation was to provide a black Alumilite® finish to eliminate reflections and to improve heat emissivity.

This end plug for aluminum tubing used in furniture was produced completely by upsetting or cold-heading a small diameter aluminum bar. The original plan called for it to be machined from a much larger bar. By cold-heading much material and machine time were saved.

Full responsibility under one roof

Advertisement

Alcoa's Up-to-Dater on Screw Machine Products (continued)

Tips on Designing for Screw Machines

This section might be called "Cost Increasers and How To Avoid Them."

One of the worst cost increasers is unnecessarily close tolerance. At Alcoa, 0.005 to 0.003 is commonplace. We can hold .001, or even less, but only at higher cost. To keep your costs down, design with as broad tolerance as possible. Where dimensions are critical to performance, then go for close accuracy. If a diameter is critical for only a portion of its length, indicate this on your drawings. Same applies to eccentricity. Locations of cross holes, milled sections, slots and similar work should be given as broad tolerance as performance of the part permits. Ditto for angular relations.

Where possible, design so the largest diameter is equal to, or near, a standard stock size (see design handbooks). If such diameters can be left unmachined, indicate it. Where outside dimensions are machined only for sake of appearance, use a standard rod size with a liberal minus allowance, including cutting away the oxide coating.

Use standard threads in American National Coarse, Fine or Extra Fine. Special threads only increase costs. Class 2 free-fit threads are most economical.

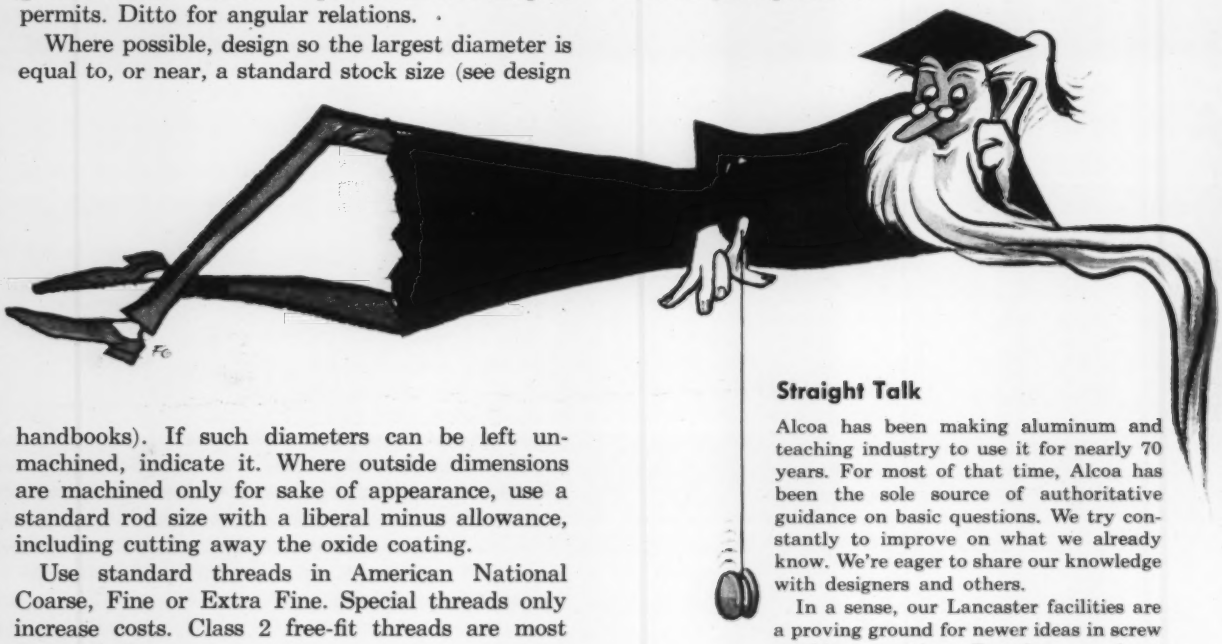
Avoid threading close to shoulders or tapping close to bottoms. In drilling, try to specify a standard drill size and allow normal point angle at bottom of hole. Flat bottom holes cost money as do those that extend deeper than six diameters. Where deep holes are required, try increasing diameter for part of depth and extend with a smaller diameter.

Deburring is costly and should be specified only where needed. Often burrs can be removed satisfactorily during finishing. Sharp corners add to cost. Those formed by intersection of turned surfaces usually can be chamfered at no cost. Chamfering at intersection of turned and unturned surfaces requires a separate operation.

Just remember that Alcoa will gladly go over your designs and point out cost-cutting modifications that often improve the product as well.

The Alloy Story

There are four main alloys important in screw machine work. Each has a specific purpose. Alloy 2011-T3, because of its lead and bismuth content, is the most machinable and should be used wherever possible. Alloys 2017-T4 and 2024-T4 are recommended where higher mechanical properties are desired; they are only a little less machinable. Alloy 6061-T6, while less machinable, is more corrosion-resistant, joins better and takes a superior finish. There are several other screw machine alloys, each for a specific need, and we suggest your Alcoa engineer is the place to find out which is the right one for your product.



Straight Talk

Alcoa has been making aluminum and teaching industry to use it for nearly 70 years. For most of that time, Alcoa has been the sole source of authoritative guidance on basic questions. We try constantly to improve on what we already know. We're eager to share our knowledge with designers and others.

In a sense, our Lancaster facilities are a proving ground for newer ideas in screw machine operations. But they are also a king-sized job shop with tremendous capacity available to all industry.

We like to bid on jobs of all sizes and all degrees of complexity. We especially like those where we can show the superiority of aluminum to other metals. So . . .

Next time you have a job calling for screw machine parts (regardless of the metal called for in your specifications) why not ask your P. A. to get a bid from Alcoa. We'd like to try for the business. We know you'd like our service. ALUMINUM COMPANY OF AMERICA, 1994-J Alcoa Building, Pittsburgh 19, Pennsylvania.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM
SCREW MACHINE PRODUCTS
ALUMINUM COMPANY OF AMERICA

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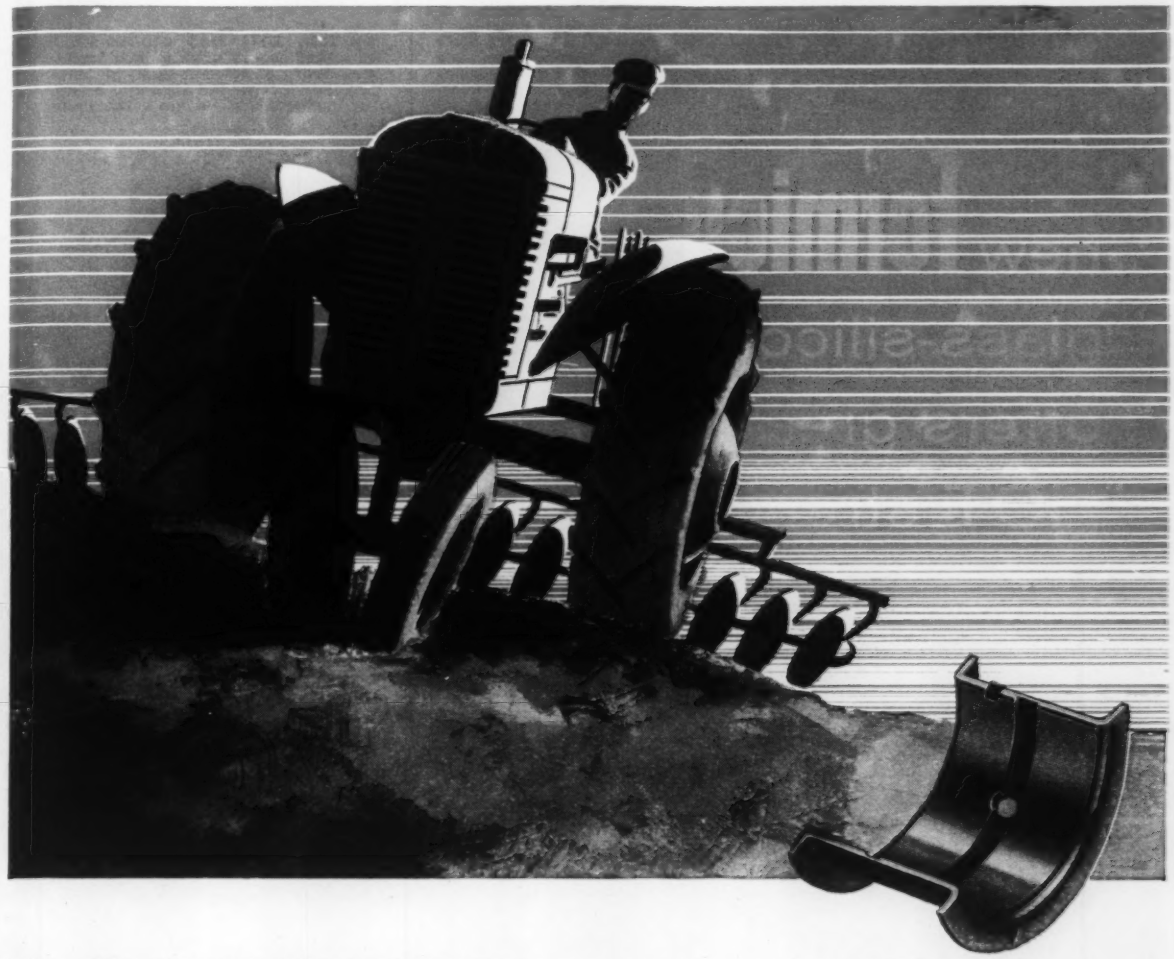
RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING



his first requirement is . . .

DEPENDABLE PERFORMANCE

Ingenious mechanical equipment has solved the labor problem for today's farmer. But his first requirement of any unit is dependability of operation—around the clock if need be—in his constant battle with nature. Federal-Mogul bearings have been assuring dependability in farm tractors and implements for generations. The same dependability characterizes Federal-Mogul bearings in any application, from automobiles to construction equipment—dependability that is the product of over 50 years' highly specialized bearing manufacture.

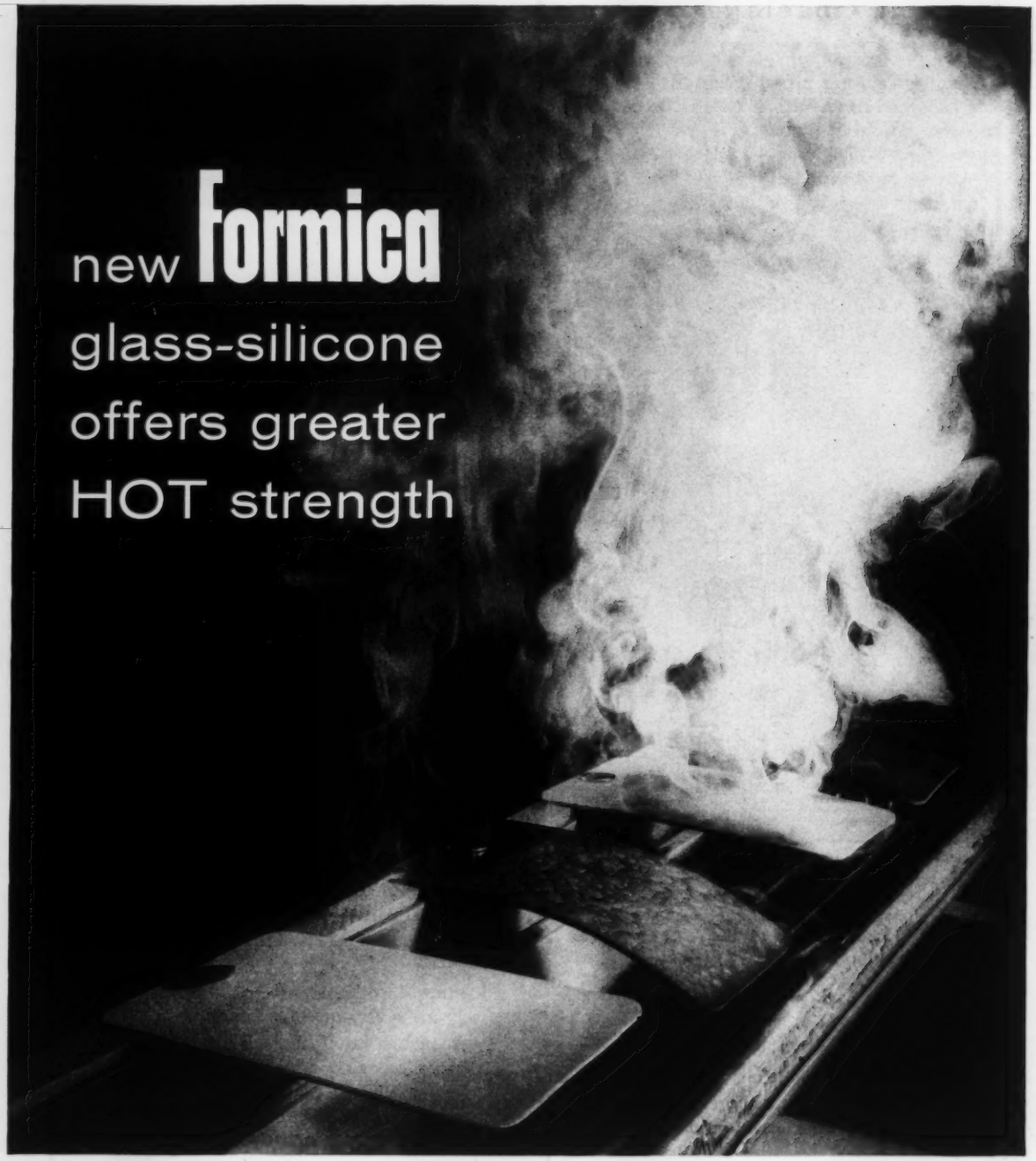
FEDERAL-MOGUL DIVISION

FEDERAL Mogul

SINCE 1899

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

Circle 529 on page 19



New Formica G-7-2 silicone offers five characteristics for broader application:

1. Greater hot strength.
2. Lower moisture absorption (.12% after 24 hrs. immersion).
3. Lower wet power factor (.008).
4. Larger and thicker sheets (up to 36″ x 72″ x 2″).
5. Uniform creamy white color.

The photo above dramatically demonstrates the outstanding hot strength property of Formica's new G-7-2. A withering blast from the lab heater causes three ordinary laminated plastics to smoke, char, blister and bend. But G-7-2 comes through this grueling test unmarked, its mechanical and electrical properties virtually unaffected.

G-7-2 is approved under military spec MIL-P-997-B, type GSG.

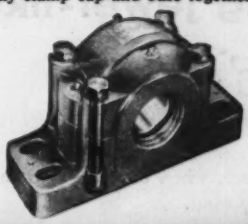
The unusual properties of G-7-2 are especially useful in guided missiles, radar, radio and tv, motors and generators and other electrical/electronic applications. Recommended for printed circuitry. For complete information, send today for free G-7-2 data sheets. Formica Corp., subsidiary of American Cyanamid, 4545 Spring Grove Ave., Cincinnati 32, O.

1st choice in laminated plastics. FI-1153
Application engineering • Fabricating
Research • Customer stock service

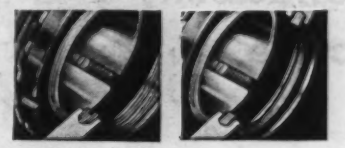
Circle 530 on page 19

MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

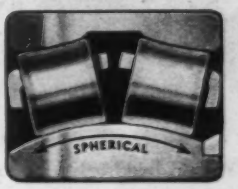
SUPER-RUGGED CAST STEEL HOUSING. Proper positioning of cap on base is assured by large-size dowels. Four heat-treated thru-bolts and serrated steel nuts firmly clamp cap and base together.

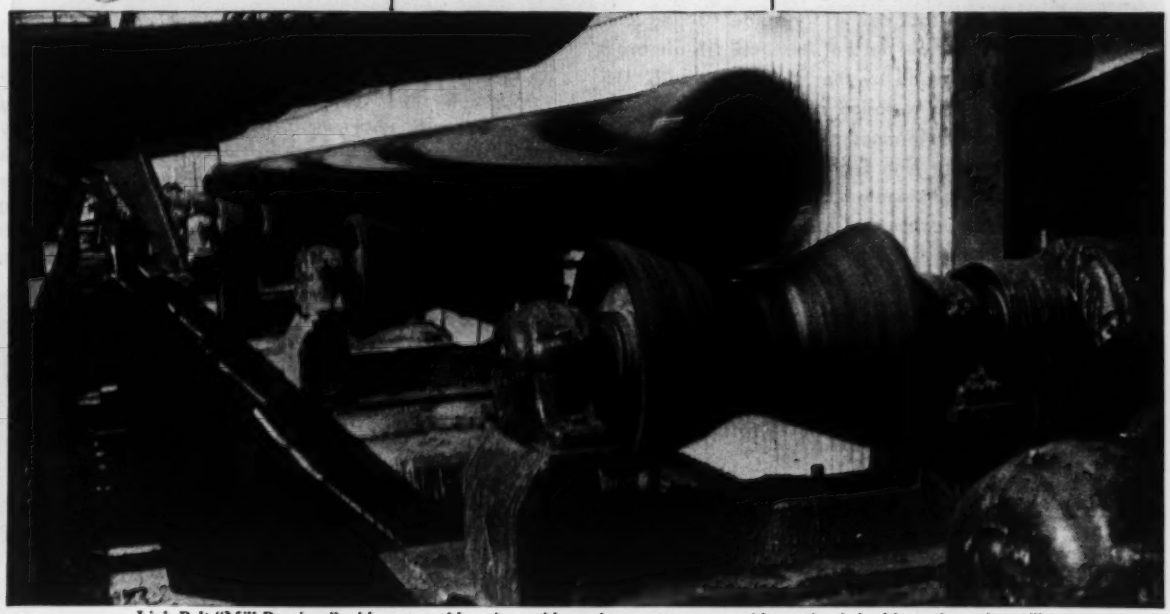


CHOICE OF SEALS. Spiral labyrinth steel seals, left, are for oil or grease lubrication and heat conditions. Combination felt and synthetic rubber contact-type seals, right, for grease lubrication.



SELF-ALIGNING ROLLER BEARING is self-contained and adjusted at the factory—needs no shims or alignment rings at installation. Design assures free rolling under even the toughest conditions.

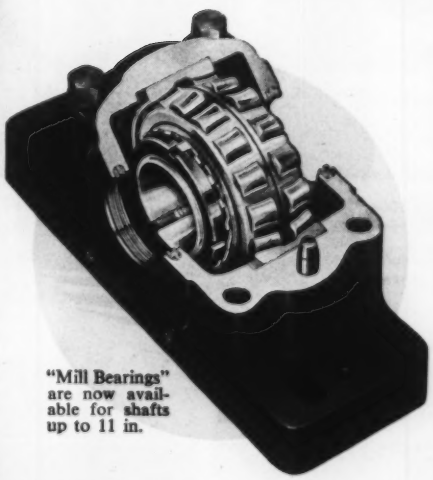




Link-Belt "Mill Bearings" with cast steel housings withstand severe impacts and heavy loads in this modern pipe mill.

"Mill Bearings" with cast steel housings

designed by Link-Belt to take industry's heaviest loads and hardest impacts



"Mill Bearings" are now available for shafts up to 11 in.

● To stand up to the sudden shocks and impact loads met in steel mills, mines, foundries, oil field applications and on heavy equipment, Link-Belt has designed the extra tough "Mill Bearing." It's the precision Link-Belt self-aligning roller bearing mounted and protected in a durable cast steel housing.

Thoroughly-proved Link-Belt "Mill Bearings" maintain full load capacity even with shaft deflections and misalignment often existing in extremely heavy service. And their simple, efficient design assures long life and free rolling.

Link-Belt makes industry's most complete line of ball and roller bearing blocks. So whatever you need, you'll find the answer in this quality line. Ask any of the 40 Link-Belt offices for Data Book 2550 and Book 2565A on "Mill Bearings."

13,982-A

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

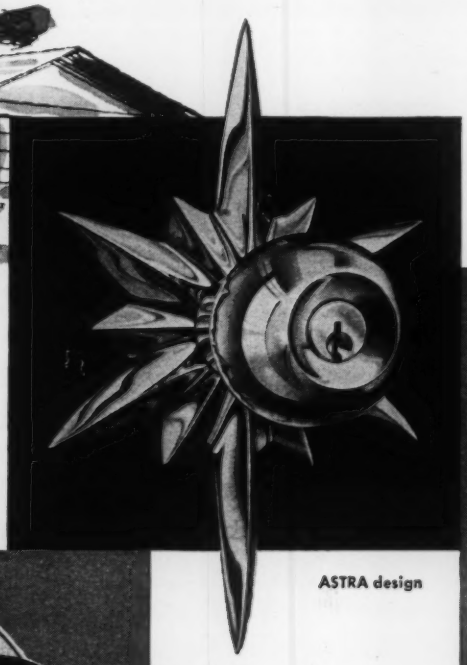
XUM

MUELLER BRASS CO.

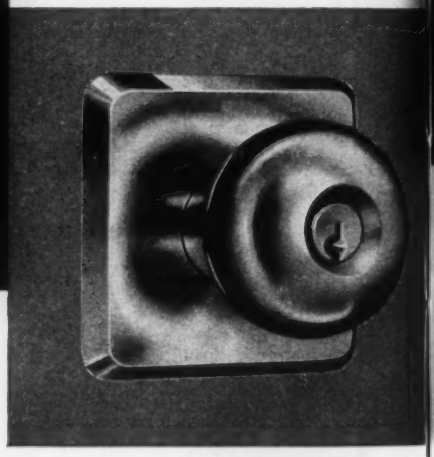
brass and bronze forgings help insure dependability and lasting jewel-like finish of distinctive SCHLAGE locks

Smart styling, handsome appearance and durability have been neatly combined by the Schlage Lock Company of San Francisco in their line of lock designs for residential and commercial use. Many important parts of these lock sets are brass and bronze forgings made by the Mueller Brass Co. The beautiful natural color, corrosion resistance, and inherent dependability of these forgings make them ideal for this purpose. In addition, the high degree of surface smoothness makes possible an exceptionally lustrous finish as well as a perfect plating surface when required. Then, too, the use of forgings has reduced costs, cut finishing time and greatly reduced the number of rejects when compared to the sand castings that were formerly used.

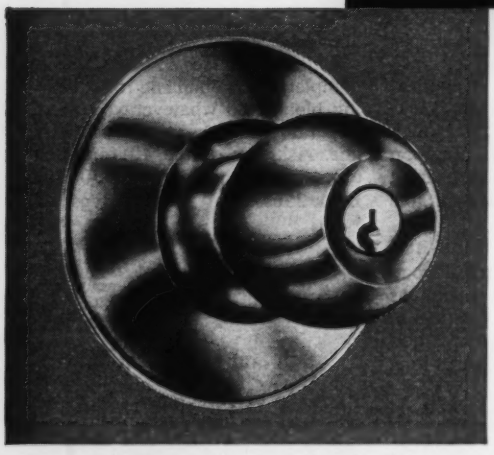
Whether you manufacture decorative hardware where finish is of prime importance or rugged assemblies that must stand up to bruising everyday punishment, it will pay you to investigate Mueller Brass Co. forgings. Strong, long wearing brass, bronze or aluminum parts, forged to your exact specifications under exacting statistical quality control standards can help you reduce costs, improve performance, and give you a better looking product. Write for our engineering manual (No. H-58565) . . . or call in one of our engineers to investigate possible forging applications in your products.



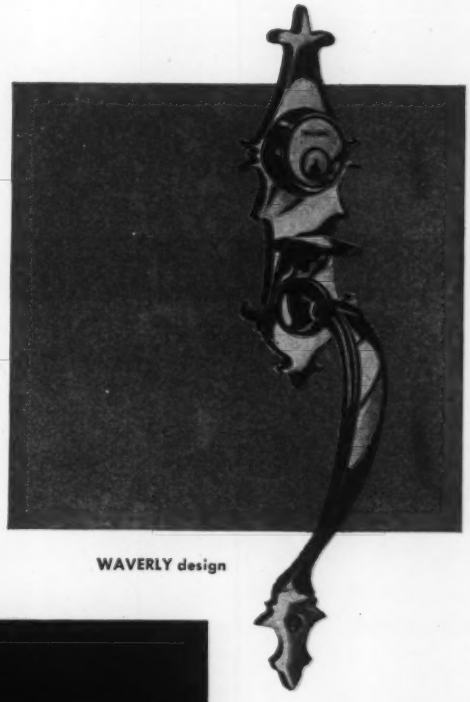
ASTRA design



MONARCH design



MERCURY design



WAVERLY design

PANTHEON design

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Mueller Brass Co. Forgings
Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys
Engineering Manual H-58563 ☐

600 Series Bearing Alloys
Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form
Engineering Manual FM-3010 ☐

METALS AND ALLOYS REVIEW

by FRANK M. LEVY
Vice-President and Director of Research

Last week one of our sales engineers was at the home office and we were talking about one of his customers in the East who manufactures milling machines which are being used for milling aircraft spars. We are supplying gibs, slide bars and wear strips to this company made of our "600" series bearing metal in rectangular rod form. The material formerly used was aluminum bronze* cast bars which they could only obtain in 36" lengths. Their engineering department estimates that costs have been reduced 50% on this component. Machining time has been reduced and impregnation of porous castings has been eliminated.

Our sales representative was curious about my experience with "600" in other applications such as this. Oddly enough, our own plant has been a pretty good proving ground. In our extrusion department, for example, we have gotten exceptionally good service from slides made of "600" and used on the die heads which are subject to pressure and extremely rough usage.

Bob Irwin of our forging department reports that the "600" strips he has used for lining the ways of our big forging presses have proved far superior to the bronzes which were original equipment. The bronze strips squashed out after protracted running. More important, the "600" strips last 10 times longer before replacement is necessary.

In our copper tube fabricating department we have a lot of automatic equipment for the production of formed tube shapes like tees and ells used in the plumbing industry. On one of the tube benders, there was no provision made for replacing worn forming slides. Our Maintenance Department reworked the machine using "600" strips as replaceable forming slide inserts. The bender is now a far more efficient machine. Because of the long life of "600", downtime on this machine has been practically eliminated.

While we were talking about these uses in our own plant, it brought to mind some other instances where the exceptionally good wearing properties of "600" have been established. A Cincinnati lathe manufacturer uses "600" in the form of counter sunk hex-headed screws on wearing strips used on lathe carriages. When the strip wears to the retaining screw the ways will not be scratched.

According to their own records, all other materials which they had tested proved unsatisfactory for the job. Another maker of precision lathes and milling machines found that after a year of exhaustive tests, the "600" metal that was used as nuts on compound slide screws outlasted competitive metals at an approximate ratio of 3 to 1 at an estimated saving of 30%.

Sliding surfaces on all kinds of machinery have different wear characteristics, as you have undoubtedly found. If you have any problems involving gibs, slide bars or wear strips that are proving troublesome, why not drop me a line or send a part print and we'll be glad to study it and make the proper recommendations.

**We manufacture 4 grades of wrought aluminum bronze.*

MUELLER BRASS CO.

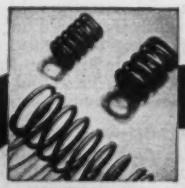
PORT HURON 15, MICHIGAN

185

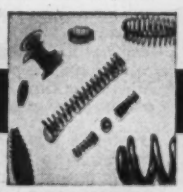
60 second tour

shows it in a nutshell . . .

All-Inclusive Spring Service

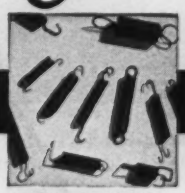


COMPRESSION SPRINGS
Regular, Double

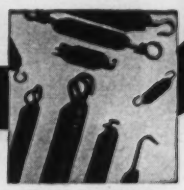


COMPRESSION SPRINGS
Special Shapes
Variable pitch

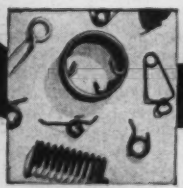
VOLUTE SPRINGS
Coned end



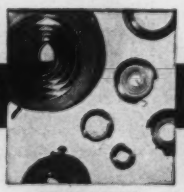
EXTENSION SPRINGS
Special Hooks
and Loops



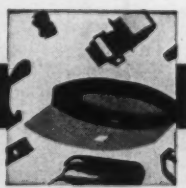
EXTENSION SPRINGS
Swivel End
Drawbar



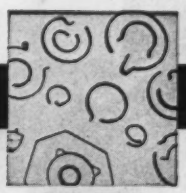
TORSION SPRINGS
Single, double
Edge wound



POWER SPRINGS
Clock or Motor

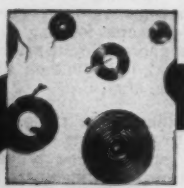


FLAT SPRINGS
Arched, Curved-beam
Elliptical



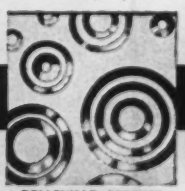
CLIPS, CLAMPS
and COLLARS

FASTENERS and
RETAINERS



HAIRSPRINGS
for Instruments
Gauges, etc.

SPRING WASHERS
Wavy, Star, Finger,
Expander, etc.



BELLEVILLE SPRINGS
In Series, Parallel
Parallel-series

DIAPHRAGMS
Discs, Plates

PLUS
COLD-ROLLED
SPRING STEEL

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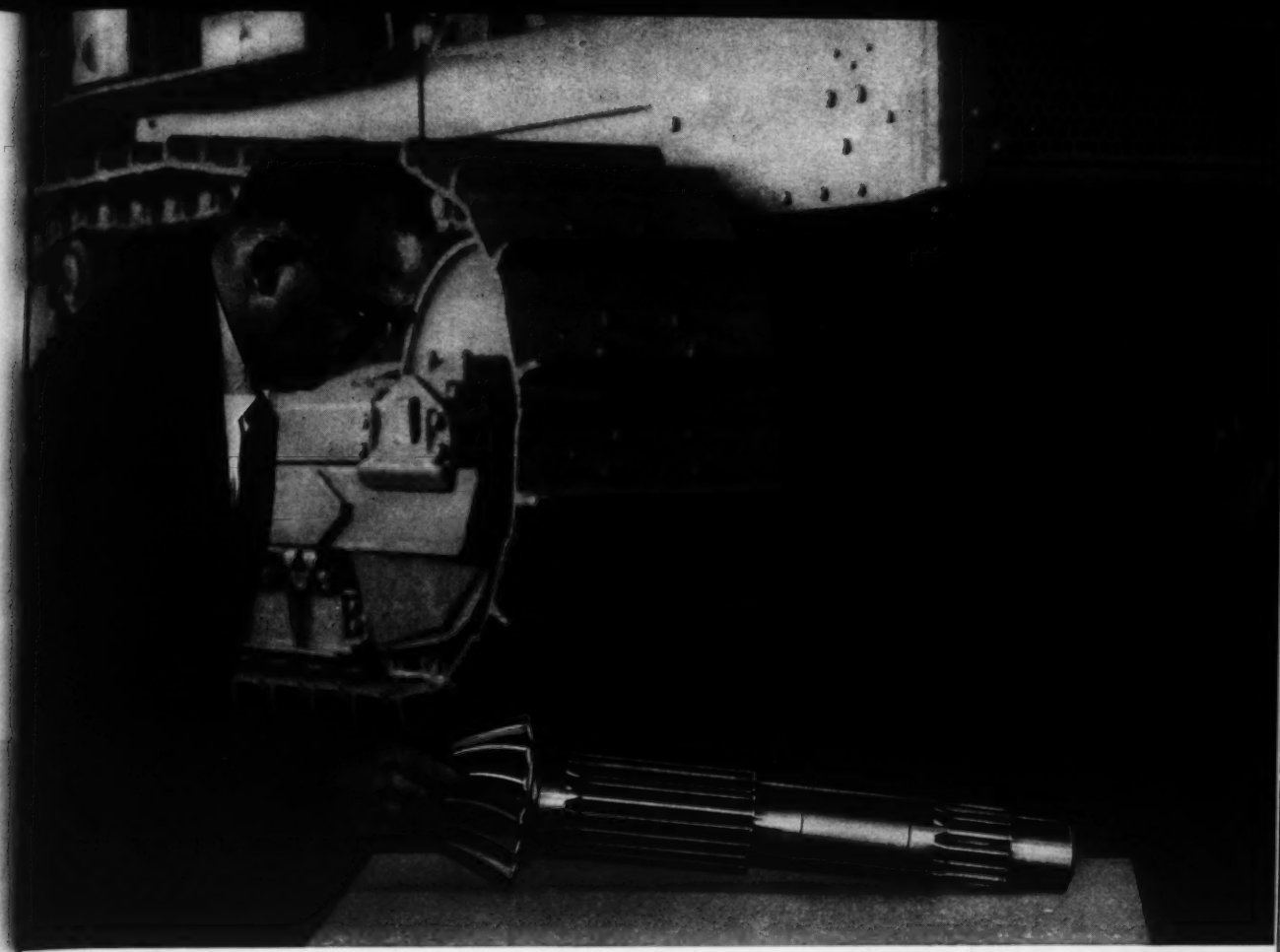


Caterpillar Tractor Co. Metallurgist T. H. Spencer inspects final drive pinion for D9 crawler tractor weighing 28 tons. Severe loading of this large pinion requires a steel with high case and core hardenability. Several years ago Caterpillar Tractor Co. found that simply by increasing the molybdenum content of AISI 8622 (to 0.30-0.40%), the desired properties were obtained at lower cost than was possible in any of the standard carburizing grades.

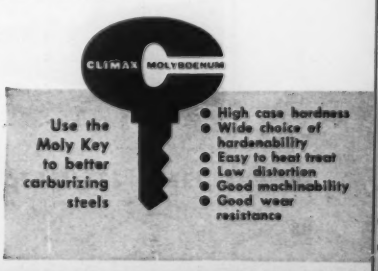
Caterpillar Tractor Co. improves case and core hardenability of carburizing steel by increasing molybdenum content

"Drive pinions in tractors must take very high torque loads," says T. H. Spencer, Metallurgist for Caterpillar Tractor Co. "AISI 8622 steel, which we had been using, couldn't give us the hard case and strong, tough core we needed in these heavy sections. Other standard carburizing steels with the requisite properties would have cost substantially more. We found, however, that we could achieve the desired surface and core properties by simply modifying AISI 8622 with a higher percentage of molybdenum. We have been using this composition for several years, and results have been excellent."

Caterpillar Tractor Co.'s experience shows how increasing molybdenum in a carburizing steel helped to solve a specific problem. Perhaps your product, too, can benefit by higher molybdenum content.

A technical article, "New Carburizing Steels for Critical Gearing", describes some recent investigations of higher-moly carburizing steels. For a reprint, write Climax Molybdenum Company, Dept. 11, 500 Fifth Avenue, New York 36, N. Y.

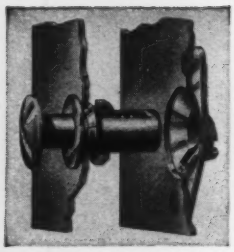
CLIMAX MOLYBDENUM

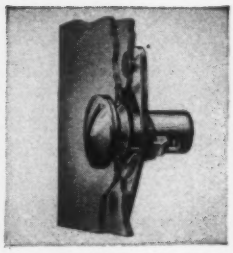

CLIMAX MOLYBDENUM
Use the Moly Key to better carburizing steels
● High case hardness
● Wide choice of hardenability
● Easy to heat treat
● Low distortion
● Good machinability
● Good wear resistance

Circle 534 on page 19

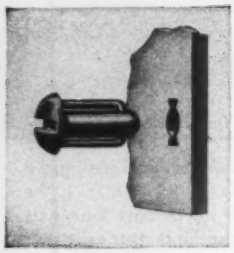
XUM

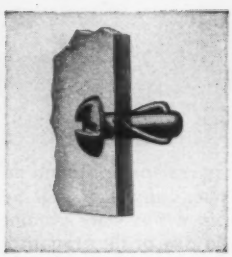
3 ways to save on assembly costs



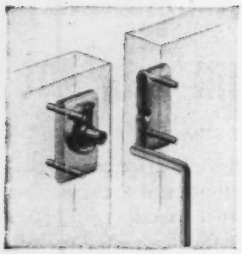


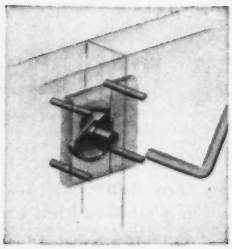
QUICK-LOCK For fastening removable access doors and panels. Because of its ease of installation, QUICK-LOCK is ideal for assembling removable panels. A 90° turn locks it in place. Stud is self-ejecting when unlocked; visual inspection shows whether fastener is locked. Spring loading takes initial load; solid supports carry increased load. Available in a wide range of sizes.





SPRING-LOCK One-piece fastener for blind holes has load-carrying steel spring wire. Spring steel arms lock fastener securely, prevent loosening under vibration. SPRING-LOCK will work with varying panel thicknesses, locks with a twist of the wrist. Made in all-metal and plastic with steel insert. The molded design permits heads to be made in various shapes for refrigerator shelf supports, washer knobs, brackets. Available in a wide variety of shapes and sizes, and also in custom designs.





ROTO-LOCK Serrated, tapered cam is engaged by formed lug as fastener is locked. Cam action draws panels together tightly, insures locking even under conditions of misalignment. Opens easily for demounting. ROTO-LOCK carries heavy tension and shear loads; can be used for air and water-tight seals: recesses completely into panels. Solidly built without springs or delicate mechanical parts, unaffected by arctic temperatures or field service.

Simmons

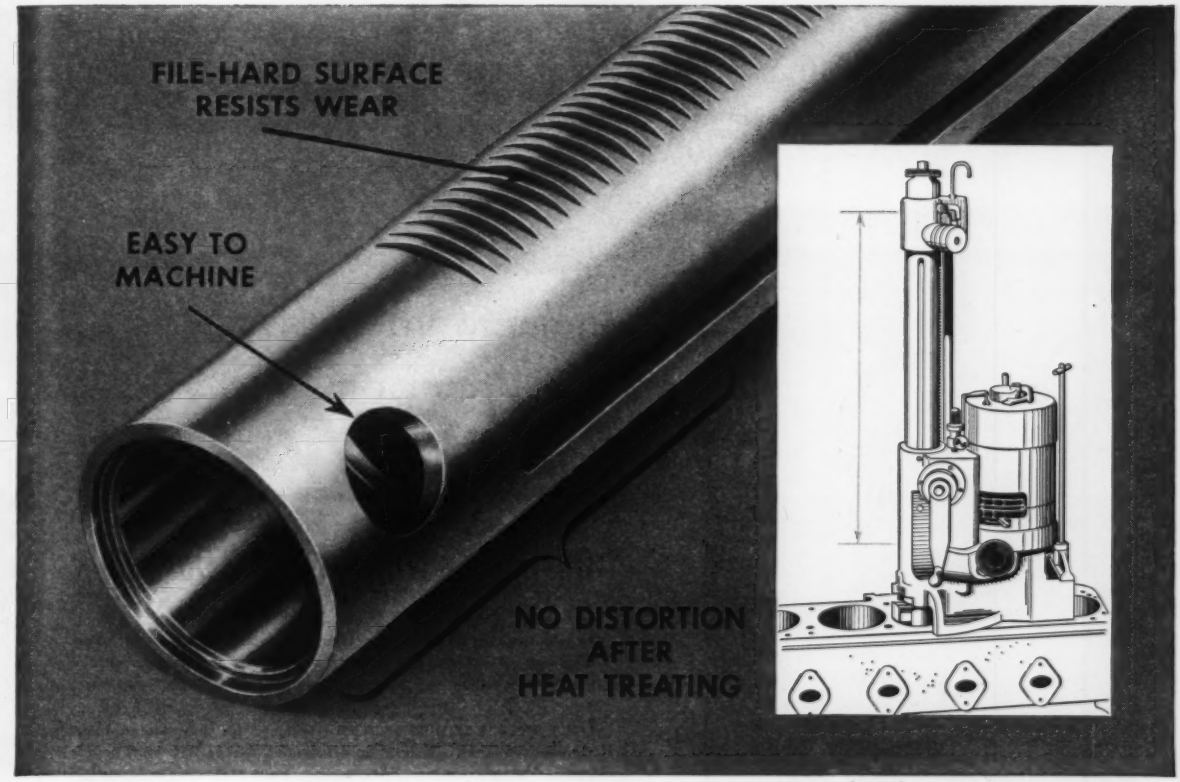
QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
SEND FOR IT

Simmons Fasteners are widely used in refrigerators, washing machines, electrical equipment, electronic assemblies, prefabricated portable shelters, coolers, demountable furniture. Every Simmons Fastener is a service-proved design with a long record of assembly-cost saving in many industries.

If you are interested in cutting your costs, turn to Simmons Fasteners—the fasteners with *uses unlimited*. Write for samples and catalogs today.

SIMMONS FASTENER CORPORATION
1756 NORTH BROADWAY, ALBANY 1, NEW YORK



Boring bar maker solves heat-treat distortion problem by switching to TIMKEN® 52100 steel

HEAT-TREATING distortion was running up the manufacturing costs of the boring bars Van Norman Automotive Equipment Company makes for reboring hard-sleeve cylinder blocks. The column of the boring bar, which acts as the spindle, had to be extremely straight. Yet many of them were distorting after heat treatment. And that meant putting them through an extra straightening process.

Studying the problem, metallurgists of the Timken Company suggested a switch to Timken® 52100 steel. Since this steel is hard and tough, it had the qualities Van Norman wanted. And because it responds uniformly to heat treatment it proved to be the answer to their production problem.

See us at the NATIONAL METALS EXPOSITION, Oct. 8-12, Public Auditorium, Cleveland, Ohio, BOOTH 1051

By switching to Timken 52100 steel, Van Norman eliminated the need for the costly straightening operation. And as a bonus, they've found that Timken 52100 steel is easier to machine than the steel they previously used.

The Timken Company pioneered the development of 52100 and is one of the principal producers of the steel—the only source of the grade in three finished forms: bars, tubing and wire. You can rely on the Timken Company for small run or emergency requirements as well as mill quantities.

We stock 101 sizes of 52100 steel, ranging from 1″ to 10½″ O.D. For a complete stock list of available sizes, grades and finishes, write The Timken Roller Bearing Company, Canton 6, Ohio. Cable: "TIMROSCO".

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

GOLD N RING

New...

Oil-tight • Water-tight • Dust-tight

Protected against oil and water seepage by Sealtight oil-resistant rubber diaphragm. Rated for 600 volts, AC or DC. Meets requirements of Joint Industry Committee and National Machine Tool Builders' Association.

EASILY REPLACES EXISTING SWITCHES — Designed for mounting in $1\frac{13}{64}$" diameter holes on standard panel mounting centers, this switch easily replaces existing switches. Accommodates panel thicknesses of $\frac{1}{16}$" to $\frac{1}{4}$" in $\frac{1}{32}$" increments. Full interchangeability of units and their components permits ready adaptation to multiple assemblies.

Units are available in flush-plate or enclosed mountings, and are adaptable for special panel assemblies.

Another product of...

National Acme

Circle 337 on page 19

Sealtight CONTROL SWITCH

Made by machine tool builders to machine tool specifications

How often have you, when designing a machine tool, wished for a control station unit designed and constructed *"as a machine tool builder would build it."*

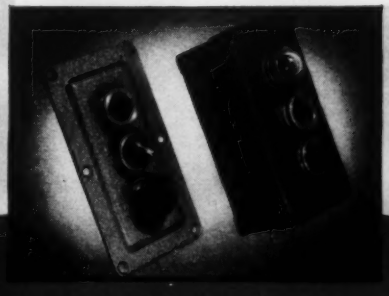
If you have been so handicapped in the past, you'll want to take a good close look at the NEW Namco GOLD-N-RING Control Station Switch Unit. Built by National Acme, builder of the world's only complete line of bar and chucking automatics, it is the *only* switch made *by* a machine tool builder *with machine tool know-how behind it.*

- **It is a heavy-duty switch in every respect.**
- **It is oil-tight, water-tight, dust-tight.**
- **Heavy-duty silver-alloy contact points provide maximum electrical capacity and long life.**
- **Heavy-duty terminal screws, with 3/8" thread contact, prevent stripping during installation and permanently secure wires for continuous trouble-free service.**
- **None easier to install; none more fool-proof.**

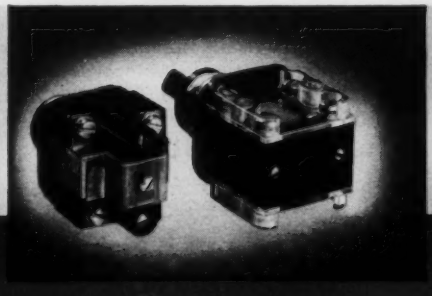
For complete details, send for Bulletin ECS-56. Better yet, ask for a representative to bring a switch for your examination.

Electrical Mfg. Division • THE NATIONAL ACME COMPANY • Cleveland 8, Ohio

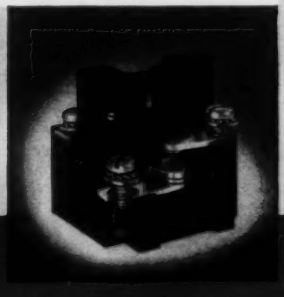
▼ **FLUSH PLATES OR ENCLOSURES accommodate any combination of individual push button, selector or pilot light assemblies. Box covers and flush plates are provided with captive screws to facilitate installation. Easy-to-read, interchangeable legend plates lock securely into position.**



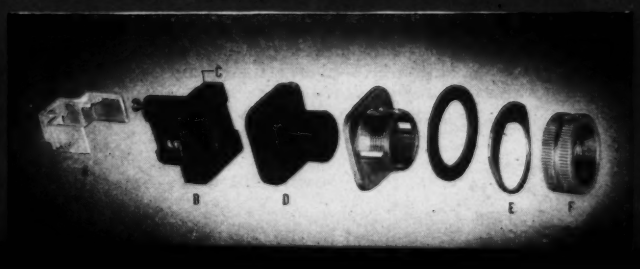
▼ **SINGLE AND DOUBLE POLE CONTACT BLOCKS can be used interchangeably with the several types of GOLD-N-RING push button and selector operator heads. Design provides easy access for secure wiring (or use of stake-on lugs) without interference. Fixed and movable contacts are completely enclosed by heavy plastic shields.**



▼ **BRASS INSERTS molded in block permanently hold stationary contacts. They also provide more thread support for the No. 8-32 terminal screws that are equipped with captive flat and lock type washers.**

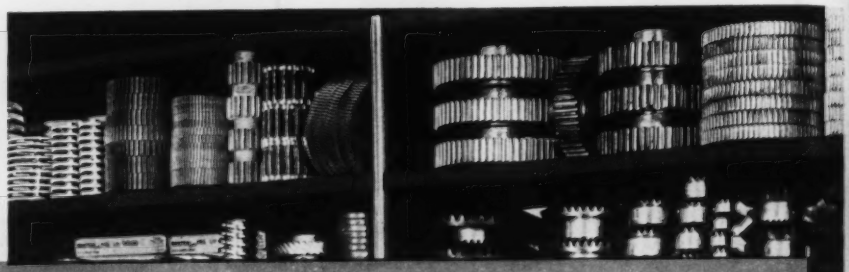


▼ **BUILT AS A MACHINE TOOL BUILDER WOULD BUILD IT! Plastic shields (A) completely enclose contacts. Blocks (B) is unit-molded to assure alignment and simplify assembly. Fully guided plunger (C) of cross-head design, prevents binding. Oil-resistant rubber diaphragm in operator head (D) completely seals out oil, water and dust. Easy-to-read legend plates (E) lock into position by "GOLD-N-RING" (F).**



▼ **INTERCHANGEABLE "GOLD-N-RING" COLLARS come in 5 different heights. Buttons can be made either extended or flush type merely by changing collar. Buttons are of non-fading glass-filled polyester and come in an assortment of colors to conform with standard codes.**

When you plan for COST REDUCTION —use this time-proved FORMULA



Selection from the BOSTON Gear CATALOG All the parts you need from the complete line of 7124 STANDARDIZED PRODUCTS

+

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- You simplify planning
- You save time and expense
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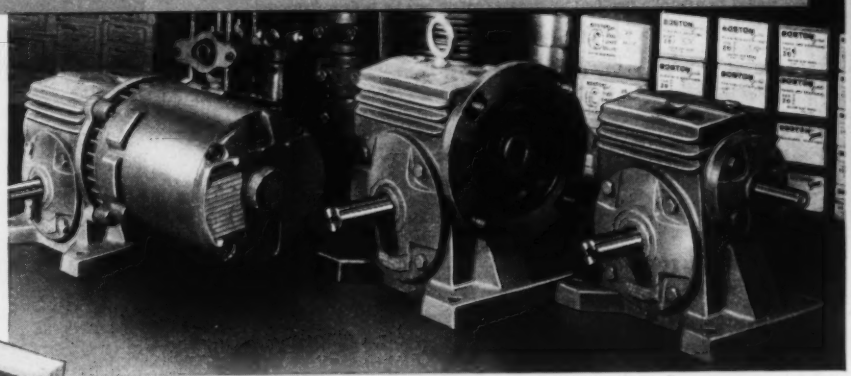

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You'll find hundreds of new products, new models, new sizes — and 50 pages of simplified Engineering Data to help you plan new efficiency, new economy in any transmission hookup. Boston Gear Works, 64 Hayward Street, Quincy 71, Massachusetts.

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— STANDARD STOCK GEARS — SPROCKETS & CHAIN — SPEED REDUCERS — BEARINGS — OTHER PRODUCTS —

56BG-NC-25A

FOR EASY FABRICATION. At Young Machinery Company, Muncy, Pa., this man, like all good welders, has no trouble with Stainless Steel in the shop. Both electric and heliarc welding are used extensively on Stainless. Fabricating operations are different, but they're not difficult.

FOR HARD SERVICE. This Kooler-Grill is made by the Victor Products Corporation. It grills 200 hot dogs per hour, heats the buns and stores plenty of ice cold drinks. USS Stainless Steel is used for all the areas subjected to hard service—where other materials would chip, dent or corrode.

NOTHING *can equal* *Stainless Steel*

in its combination of desirable properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

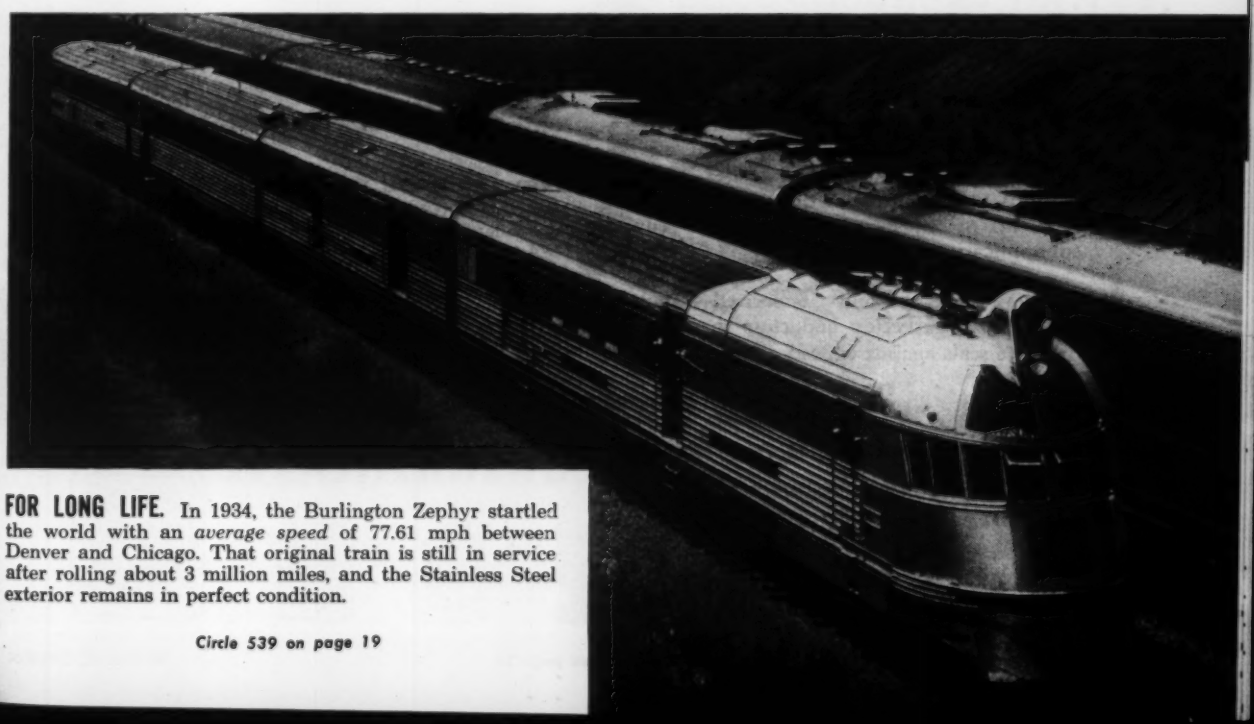
UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

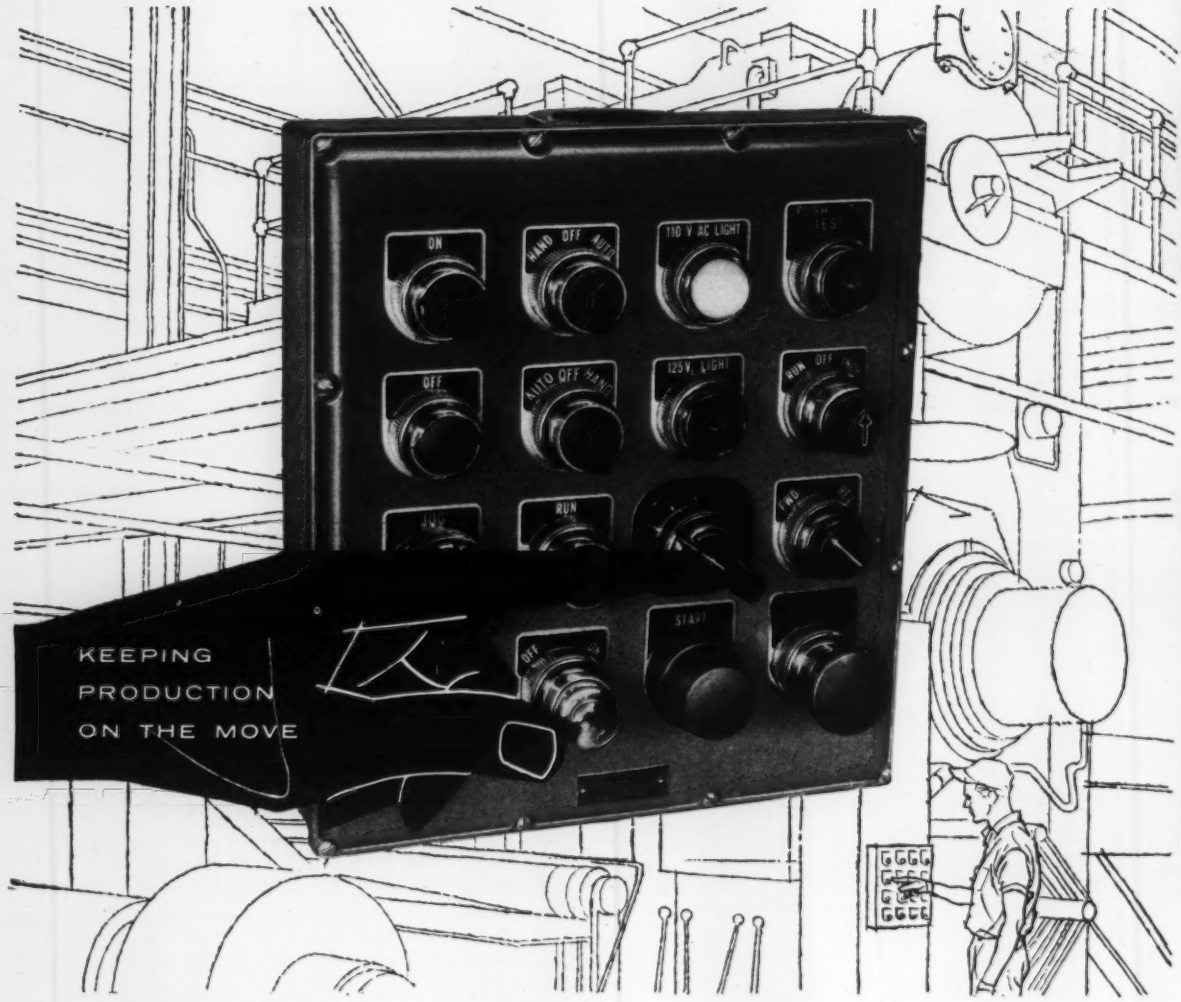
USS

UNITED STATES STEEL



FOR LONG LIFE. In 1934, the Burlington Zephyr startled the world with an *average speed* of 77.61 mph between Denver and Chicago. That original train is still in service after rolling about 3 million miles, and the Stainless Steel exterior remains in perfect condition.

Circle 539 on page 19



. . . with Westinghouse Oil-Tite control stations—1 to 16 units

Interchangeable parts — stations, contact blocks, operators and indicating lights — right off the shelf, quickly give you a "tailor-made" Westinghouse Oil-Tite* control station to meet the requirements of any heavy-duty industrial equipment application.

Enclosures — die-cast and Bonderized — include cork-neoprene gasketing and close machine fits as positive seals against exposure to oil, coolants, cutting compounds, water and other foreign matter.

*Trade-Mark

New Pushbutton Guide

For more facts on why it will pay you to standardize with Westinghouse control stations, get a free copy of the new *Pushbutton Guide,* booklet B-6749. See your nearby Westinghouse salesman or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-30210

WATCH WESTINGHOUSE!

WHERE BIG THINGS ARE HAPPENING FOR YOU!

THERE'S A WESTINGHOUSE PUSHBUTTON TO MEET EVERY APPLICATION NEED!

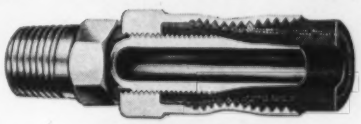
Circle 540 on page 19

WEATHERHEAD

First in components for HYDRAULIC SYSTEMS

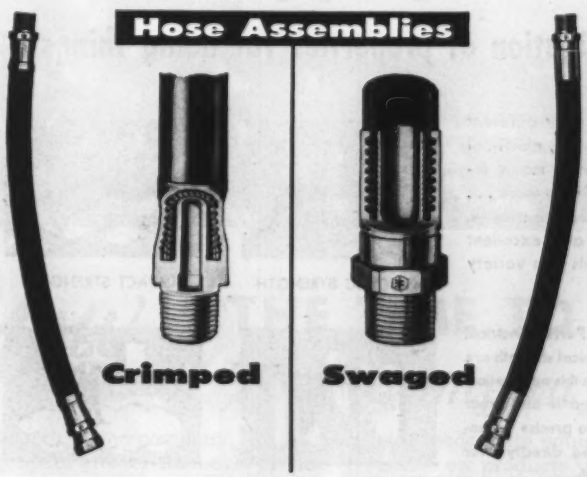
Look at anything . . . anywhere in the world . . . in hydraulics, diesel power or machine tool applications . . . equipment for instrumentation, oil drilling, mining, road building, petro-chemicals or even atomic power . . . chances are the vital air and fluid lifelines are secured with WEATHERHEAD.

Reusable Hose Ends



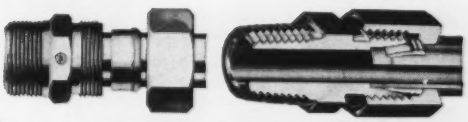
Bulk Hose

Hose Assemblies



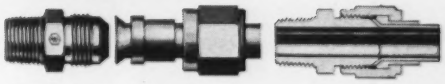
Crimped **Swaged**

ERMETO



SAE 37° FLARE

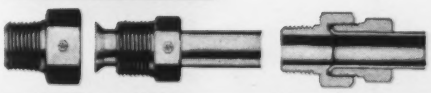
3-PIECE



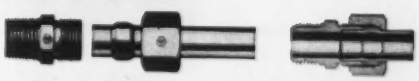
2-PIECE

SAE 45° FLARE

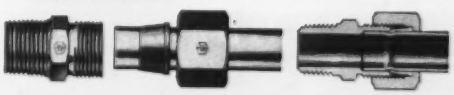
INVERTED FLARE



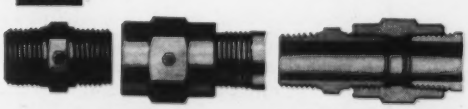
COMPRESSION



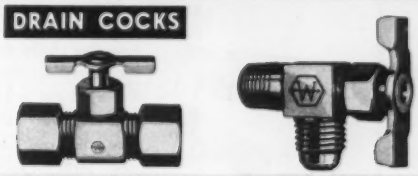
SELFALIGN



PIPE



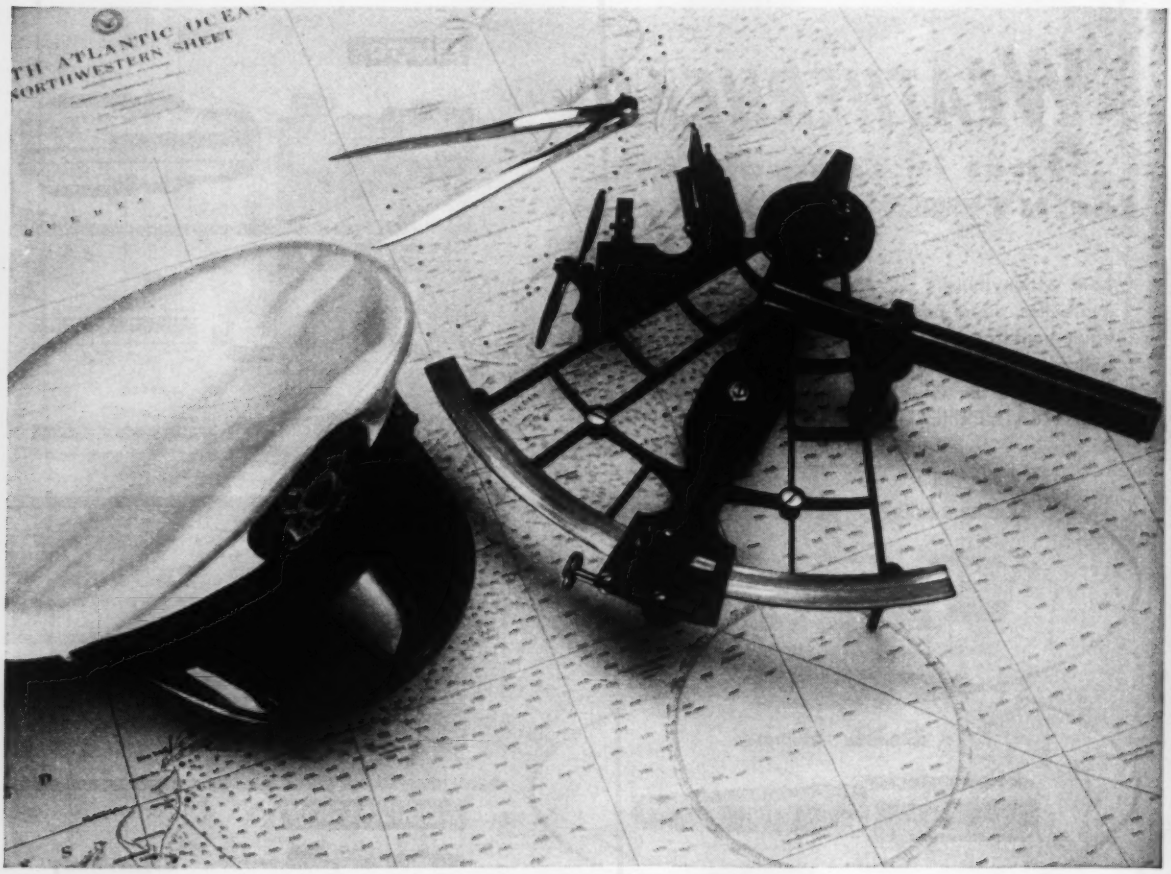
DRAIN COCKS



WEATHERHEAD
FIRST IN HYDRAULIC CONNECTIONS

THE WEATHERHEAD CO., FORT WAYNE DIVISION
Dept. AB-9, 128 West Washington Blvd., Fort Wayne, Indiana
In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario

WEATHERHEAD
The only single-source hydraulic hose and fitting line.
Available coast-to-coast through Weatherhead distributors.



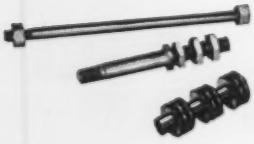
A combination . . . for going places

Laminated plastics . . . a combination of properties for doing things

Synthane laminated plastics work for industry in so many different ways because of their unusual combination of mechanical, electrical and chemical properties. Engineers in practically every major industry have put Synthane's many combination properties to work . . . providing unusual strength and toughness, high insulation resistance, low moisture absorption, good dimensional stability, and excellent resistance to corrosive acids, alkalies, salts and solvents in a variety of products.

DIELECTRIC STRENGTH

IMPACT STRENGTH



Synthane Power Shovel Parts. Electrical insulating ability and mechanical strength are the properties most needed in this application. The Synthane grade selected is also wear resistant, easily fabricated to precise dimensions, and can be laminated directly over metal cores for extra strength.

HEAT RESISTANCE

LIGHT WEIGHT

A Synthane grade for you! Synthane offers over 30 individual grades in sheets, rods, tubes, moldings and completely fabricated parts. Send for free illustrated catalog today.

SYNTHANE

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

Circle 542 on page 19

Circle 543 on page 19→

Production Boom Putting on Pressure for Greater Drafting Room Output?

Now IS THE TIME TO ACT *in Behalf of Your Company and Yourself!*

Chances are that your company, like most, is gearing up for greater-than-ever production. That means more and more pressure on your drafting department for engineering drawings and prints. You owe it to your company and yourself to equip your department, right now, to meet growing demands with greater output!

New, higher-production equipment and materials can help you do it! Never has there been a better opportunity to replace old, inadequate equipment with the efficient new products you've been wanting. With management's desire for greater production, you couldn't pick a better time to get approval for new equipment expenditures.

BRUNING

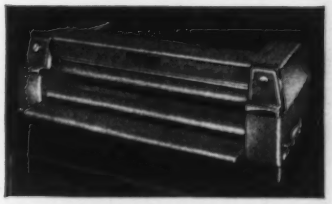
To discover for yourself how many ways you can boost drafting room output, yet save time and manpower, take a minute to look over the next three pages. You'll be glad you did!

Look How Many Ways You
Save Time and Money With

Check the Places in Your Drafting Room Where Production Bottlenecks Can be Eliminated by Modern Bruning Products!

(1) Modern Copyflex Machines Speed Reproduction, Cut Operating Costs

Five new and advanced machine models introduced in just the last year! They offer you all the benefits of diazo black-on-white reproduction, plus problem-free installation and operation. No fumes, no exhaust ducts. They bring you faster reproduction speed and a host of operator conveniences such as fast return of originals, automatic separation, front or rear delivery. There's a Copyflex model to meet every need. New, better Copyflex sensitized materials work together with Copyflex machines to give you premium results.



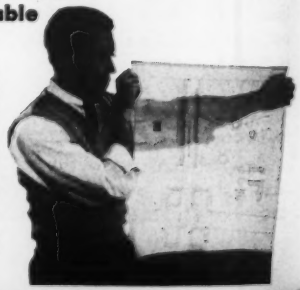
JUST OUT! New Tabletop Model 300 with 30-inch printing width! Now the smallest engineering department can afford the advantages of "inside" reproduction with low-cost Model 300. The largest company can economically supplement its reproduction center with additional, strategically located Model 300s.

(2) Modern Bruning Drafters Speed Drafting up to 30%

Over conventional equipment, Bruning drafters speed drafting up to 30% on most jobs . . . up to 40% on some structural drawings. Patented "Equipoise" gravity compensator, exclusive touch control indexing provide unrivalled simplicity, precision, and ease of operation. Full range of models including Counterbalanced and Track Drafters. Standard or Civil Engineer protractor heads.

Modern Bruning Tracing Mediums (3) Speed Drawings, Enable Sharper Prints

These improved drawing mediums are unsurpassed for translucency, pencil-and-ink taking qualities, and permanence. You make drawings and tracings far easier and faster, get cleaner and sharper prints. Select from a complete variety.



Can Boost Drafting Room Output, New, Modern Bruning Products!

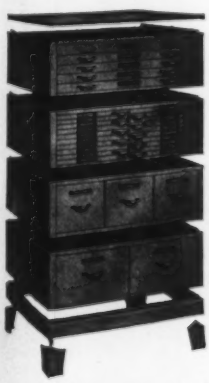
Why Let Old and Inadequate Equipment and Materials Stall Operations Now, When More and More Output Is Demanded of Your Department? Every Day You Delay Is Costing You Time and Money!

Here are the modern, higher-production products—some the newest on the market—that can help you boost drafting room output by replacing old and inadequate equipment and materials. A pioneer researcher in its field, Bruning still leads the way today with such developments as newly improved tracing papers and cloths that are setting a new standard in their field . . . newly improved sensitized materials that give you quality reproduction never before attainable . . . new, improved Copyflex machines that set a new high in quality, convenience, and economy of reproduction.

Researcher, manufacturer, and supplier . . . Bruning provides you a single, convenient, dependable source for everything you need in top-quality drafting room supplies and service. You simplify ordering and stocking, save time and money. Companion products, like Copyflex reproduction machines and Copyflex sensitized materials, are made to work together to give you premium results.

(4) Modern Hamilton Drafting Tables Provide up to 50% More Use of Floor Space

You can put six Hamilton Auto-Shift tables where you now have four boards with separate reference desks. The unique design of Auto-Shift increases the efficiency of draftsmen, reduces waste motion and fatigue. Bruning has a modern drafting table to suit every need and budget.



(5) Modern Hamilton UnitSystem Files Save Time, Space; Permit Orderly Expansion

You choose the individual filing units you need and combine them in an integrated and interlocking stack. You save time because drawings are easier to file and find. You make the most efficient use of space, expand your filing set-up in an orderly fashion.

More Products from Bruning to Help You Step up Production, Save Time and Money!

Modern Drafting Tools and Supplies Help Speed Draftsmen's Work

Bruning's wide selection includes not only standard items, but many special time-saving aids such as dotting pens, proportional dividers, planimeters, and Wrico lettering sets.

Modern Bruning Erasing Machines Save Hours of Manual Erasing

Do a neater, safer erasing job. Save hours of finger-cramping manual erasing. Patented hollow shaft permits use of extra-long, seven-inch eraser, prevents "fly-outs." Quiet, cool, vibration-free.

BRUNING *Gives You More to Help Boost Output*

3 More Reasons

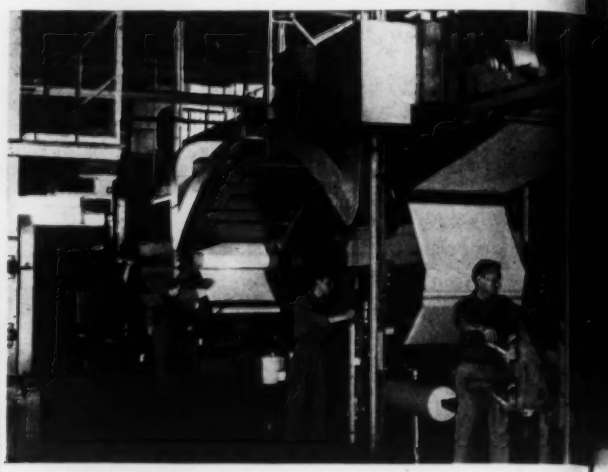
Why You Can Depend on Bruning to Help You Boost Drafting Room Output, Save Time and Money!

New and Better Products
—from Bruning Research and Engineering

In the past, it was Bruning Research and Engineering that introduced the first pencil tracing cloths, the first fume-free whiteprinters in America, the first band-type drafting machines. Today, by virtue of its modern laboratories and large engineering staffs, Bruning still leads the way in the development of new and better products. In just the past year, Bruning introduced five new, advanced reproduction machines . . . many newly improved tracing materials.

The Product and Help You Need When You Need Them—from Bruning Sales Service

With the most comprehensive network of sales-service branches, distributors, and plants in its field, Bruning assures you of prompt, dependable service and supply. Your nearby Bruning branch is headquarters for a capable staff of Bruning sales-service specialists who are immediately available to you. Your nearby Bruning branch or distributor carries a full line of Bruning products and is staffed and equipped to give you fast, efficient supply. You suffer no costly delays for lack of supply or service.



Consistently High Quality
—from Bruning Manufacturing

In its own modern paper converting plants at Teterboro, N. J., Chicago, Kansas City, Los Angeles, and Toronto, Ontario, Bruning controls quality all the way to bring you tracing mediums and sensitized materials of dependable, consistent high quality. The famous Copyflex reproduction machines are entirely Bruning manufactured to provide you the finest in reproduction performance.

America's Leading Supplier of
Engineering and Drafting Equipment

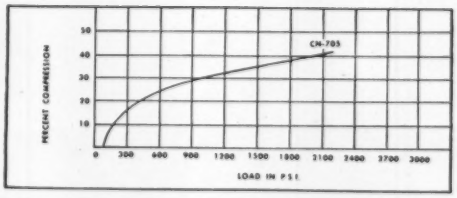
BRUNING

There you have it—the "big package" from Bruning to help you meet the demand for greater drafting room output! You get a complete line of modern, high quality products! You get better service. They work together to bring you better results at lower cost.

Charles Bruning Company, Incorporated
4700 Montrose Avenue, Chicago 41, Illinois
In Canada: Charles Bruning Company (Canada) Ltd.
105 Church Street, Toronto 1, Ont.

Printed in U.S.A.

Accopac® fiber gasket maintains bolt torque, won't leak



LOAD-COMPRESSION CURVE SHOWS high compressibility of Armstrong CN-705 Accopac. With light metal flanges, this compressibility allows gaskets to seal under light bolt pressure.

Armstrong CN-705 Accopac maintains bolt torque—and seals tightly—at pressures up to 2000 psi and temperatures to 250° F.

This improved gasket material is made by a patented beater-saturation process which locks cellulose fibers and cork particles in a latex binder. This produces a material with both excellent "kickback" . . . and impermeability to liquids and gases at pressures as low as 800 psi.

CN-705 keeps a tight seal even in alternately wet and dry applications. That's because it won't shrink or dry out: its nitrile rubber binder is non-volatile and non-extractable.

CN-705 Accopac is resilient and highly compressible. It conforms to normal surface irregularities on stamped flanges and on rough-finished cast flanges.

For data sheet and samples of CN-705 Accopac, write to Armstrong Cork Company, 7009 Dean St., Lancaster, Pa.

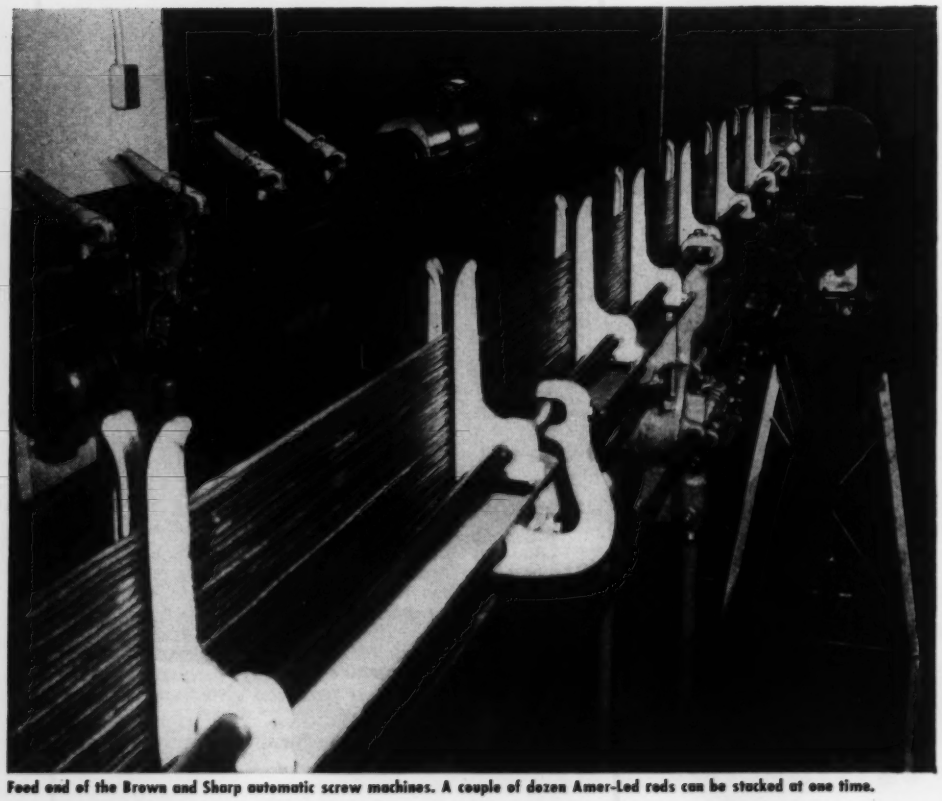
Armstrong ACCOPAC

. . . used wherever performance counts

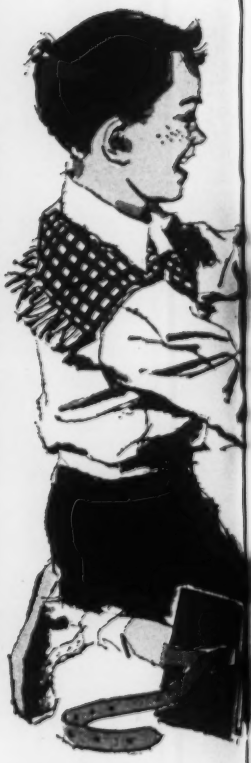
Circle 544 on page 19

How "MASTER" put a

USS Amer-Led hikes



Feed end of the Brown and Sharp automatic screw machines. A couple of dozen Amer-Led rods can be stacked at one time.



Business end of the screw machines. Increased production was most noticeable here, where shackles are cut, formed and drilled.

Broaching is performed on this Zeh and Hahneman toggle press. Tool life is much greater since use of Amer-Led.

padlock on costs...

production 25% to 75%

When American Steel & Wire first developed Amer-Led free machining stock, it was suggested to Master Lock and it worked like a charm. Automatic screw machine production leaped 25% to 75% without any increase in tool wear! The finer grain structure of this new steel permitted more accurate cutting to closer tolerances, and there were fewer rejects, too.

Punch press production increased 15% to 20%, and was limited only by the ability of the operator to feed the machine. Although production was not increased in the broaching operation, tool life was increased.

Of course, this is the story of Master Lock Company. If *you* yearn for results like this, then get in touch with your AS&W representative. Ask about USS Amer-Led.

Schoolboys can identify a "Master" padlock with its unusual laminated steel case. The shackle is possibly the most important part. Miscreants try to twist it off with a crowbar, or sever it with hacksaw or rasp. Obviously, the shackle must be hard and free from brittleness after heat treatment; and during production it must be ductile and machinable.

The Amer-Led is stored as received—in steel strapped bundles. There's a type for most machining operations.

AMERICAN STEEL & WIRE
DIVISION, UNITED STATES STEEL
GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

AMER-LED
SUPER-MACHINING
BARS

USS

UNITED STATES STEEL

Circle 545 on page 19

A Two extension coil springs hold assembly against shaft.

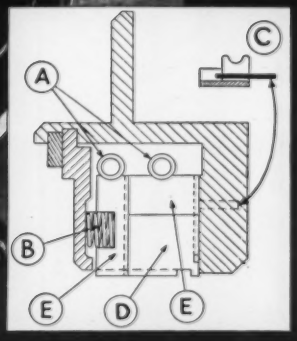
B Axial compression springs exert constant positive pressure toward the sealing face.

C Key and pin assemblies lock carbon segments against rotation.

KOPPERS CIRCUMFERENTIAL SEAL

PROVIDES UP TO 2000 hrs. OF PERFORMANCE

CAN USE LESS THAN 5 h.p.



D Flexible sealing segments permit seal to achieve same circularity as shaft.

E Straight-cut joints are covered and sealed by segmental cover ring and segmental back ring.

A number of finite joint gaps allow for ring wear.

Koppers Circumferential Seal is a segmented carbon seal ring with straight-cut joints. Its design can be modified to use step type joints or step seal joints. Primarily a gas seal, the Koppers Circumferential Seal will seal liquids if the geometry of the shaft mating faces is changed.

Koppers Circumferential Seals are one of a large variety of seals designed and manufactured by Koppers for every industrial use. Because of this complete line, Koppers can recommend, without bias, the seal best suited to your specific application. And Koppers continuous development and testing of new designs and new materials assure you of the most advanced, most efficient seals for your purpose. If you have a sealing problem, write to the KOPPERS COMPANY, INC., Metal Products Division, Piston Ring and Seal Department, 2309 Scott St., Baltimore 3, Maryland.

Engineered Products
Sold with *Service*

KOPPERS

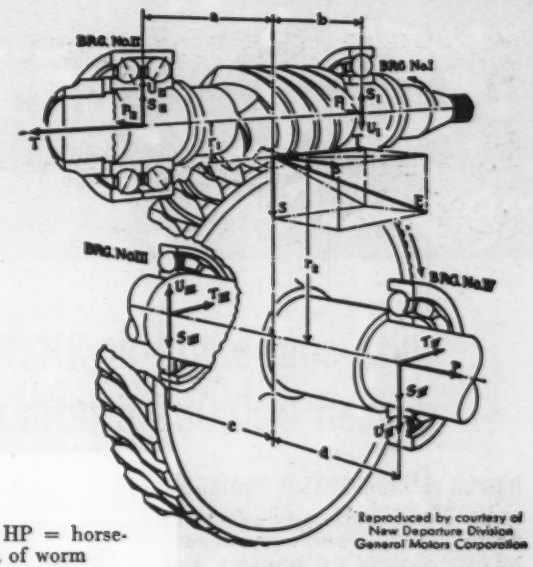
MECHANICAL SHAFT SEALS

Circle 546 on page 19

(Advertisement)

Helpful Data from
DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \frac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \frac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches

[r_2 = Pitch radius of worm gear

$= \frac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \frac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where

α = Axial tooth pressure angle*

γ = Helix or lead angle of worm*

$= \tan^{-1} \frac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \frac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \frac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \frac{a}{a+b} = P_I$	$P \frac{b}{a+b} = P_{II}$
S	$S \frac{a}{a+b} = S_I$	$S \frac{b}{a+b} = S_{II}$
T	$T \frac{r_1}{a+b} = U_I$	$T \frac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$

Due to	on Brg. III	on Brg. IV
P	$P \frac{r_2}{c+d} = U_{III}$	$P \frac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \frac{d}{c+d} = S_{III}$	$S \frac{c}{c+d} = S_{IV}$
T	$T \frac{d}{c+d} = T_{III}$	$T \frac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

Speed Change

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

If you have a problem in the selection or application of worm gearing, De Laval engineers will be glad to put their experience to work for you. Either write us giving complete details, or consult your local De Laval representative. De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

DL 941

"Bet a fish it's got **SKF** bearings!"

Don't take that bet, bird – unless you have fish to burn!

SKF is the company that sells *all four* basic types of bearings. And that means you'll find our bearings in more applications... in more places in the world... than any other bearings. In everything from roller skates to roaring jets, these bearings literally make the world go round. *Plus-quality* **SKF** Bearings are serving your industry, your family and you right now! 7720

SKF—EVERY TYPE—EVERY USE

SKF®

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings ("Tyson")*

*Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

Circle 547 on page 19

DU PONT ELASTOMERS

NEOPRENE · HYPALON

in Design

HYPALON® can be compounded in an unlimited range of weather-resistant colors

HYPALON, Du Pont's new synthetic rubber, brings brilliant and varied colors as well as superior performance to the design field. Colored compounds of HYPALON start bright . . . *stay* bright despite severe exposure conditions indoors or outdoors. The samples shown above, for example, were subjected to two years of outdoor exposure. There is virtually no change in color and negligible change in physical properties.

In addition to outstanding color stability, HYPALON has many other advantages that can help your products give *extra-long service* on industry's toughest jobs. Compared to other kinds of rubber, HYPALON shows unusual resistance to hardening at elevated temperatures (250° to 350°F.). It is completely resistant to ozone and has exceptional resistance to strong oxidizing agents.

When your design calls for a resilient material that must have exceptional resistance to these conditions, it will pay you to take a close look at HYPALON.

Circle 548 on page 19

NEOPRENE air-brake tube still in service after 5,500,000 flexings

No downtime in 4 years

The brake element shown is part of a clutch-and-brake unit which is capable of stopping heavy rotating equipment within 1/10 of a second. One such unit has piled up a record of 5,500,000 engagements in four years *without any maintenance*. The key to this kind of performance lies in the design of the machine and in the use of two rayon-reinforced neoprene tubes.

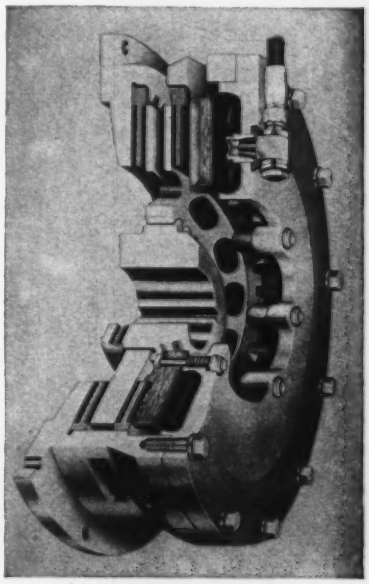
Typically, two of the pictured elements are used together, one serving as the clutch, the other as the brake. When the stop switch is thrown, compressed air is released from the neoprene tube in the clutch element; this disengages friction plates in the clutch and disconnects the drive motor from the driven machine. At the same time, in the brake element, compressed air is admitted to the neoprene tube, engaging friction plates and halting the machine.

Neoprene resists oil, high temperatures

Neoprene's superior oil resistance and durability at high temperatures have made the performance of this clutch and brake possible. Natural rubber tubes previously used were deteriorated by heat and by the oil that almost invariably gets into any compressed-air supply. They swelled, and the inside surfaces tended to become tacky and stick together. When rayon-reinforced neoprene air tubes were used, the problem was solved.

Neoprene makes a better design

In designing new products or improving old ones, neoprene stands up where ordinary resilient materials fail. Neoprene offers the designer resistance to oil, heat, weathering, chemicals and abrasion. It improves product performance—cuts maintenance costs. Complete property data and typical neoprene application data are available.



SECTIONAL VIEW of brake element, with Neoprene air tube in red

DU PONT
REG. U. S. PAT. OFF.

HYPALON is a registered trademark of E.I. du Pont de Nemours & Co. (Inc.)

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Please send further information and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old. I am particularly interested in

_____

_____

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-9
Wilmington 98, Delaware

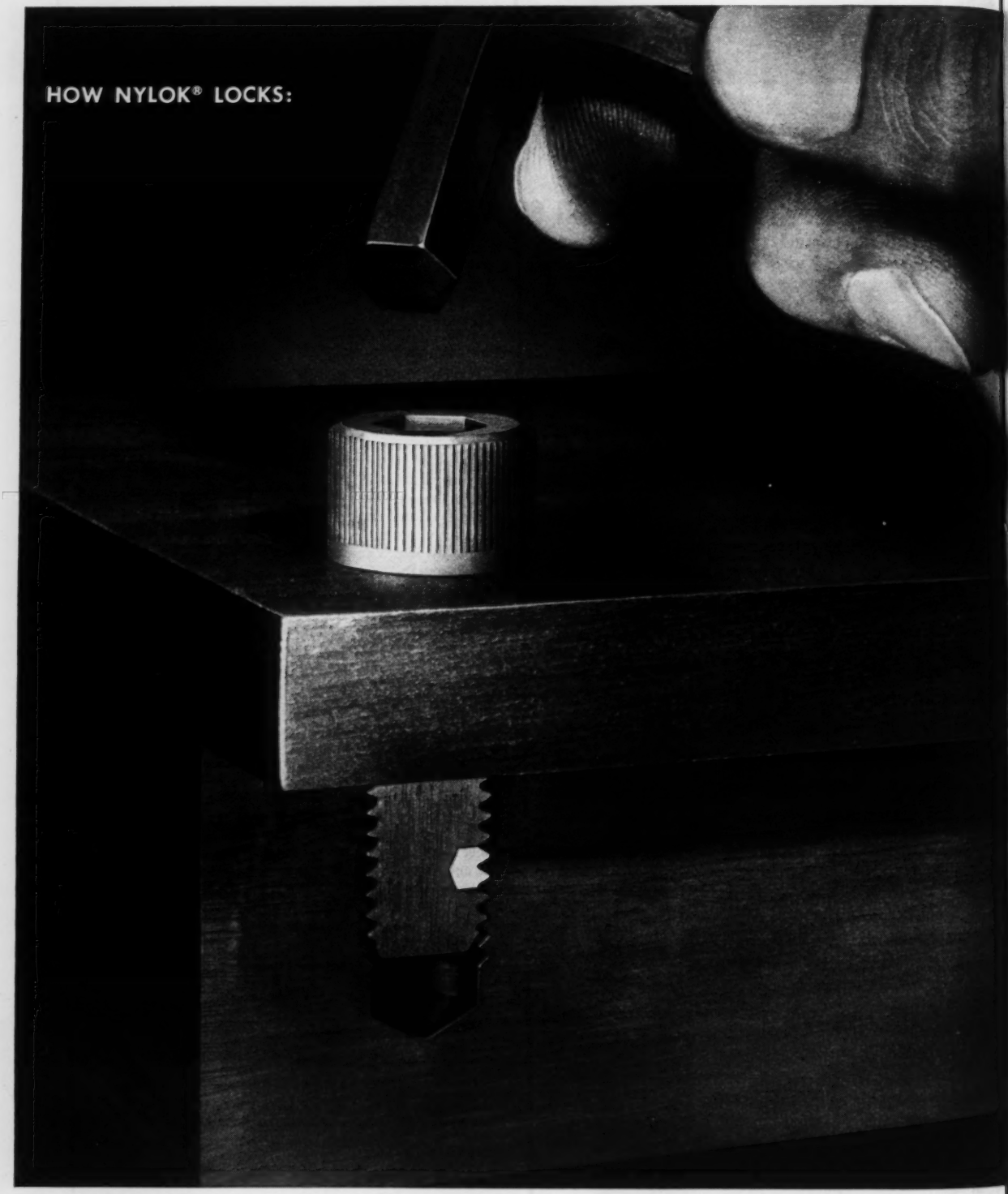
Name _____ **Position** _____

Firm _____

Address _____

City _____ **State** _____

NEW—self-locking UNBRAKO

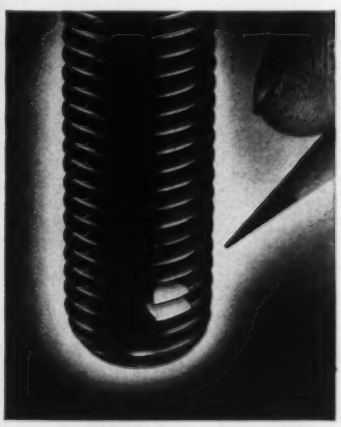


LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together and locks the screw securely.

socket head cap screws

Self-locking UNBRAKO socket head cap screw.

BEFORE ASSEMBLY. The nylon pellet projects slightly. When assembled, threads will be impressed into it.



AFTER REMOVAL. "Plastic memory" of pellet has expanded impressed threads to greater diameter than screw threads. Screw can be used repeatedly. In use, "memory" keeps threads tightly locked.

They won't work loose. And they simplify design and save production time.

UNBRAKO socket head cap screws are now available embodying the Nylok* self-locking principle. Nylok provides the first truly practical solution to the problem of making cap screws self-locking.

An UNBRAKO cap screw with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Just thread the UNBRAKO into any tapped hole. *Seated or not*, it locks positively wherever wrenching stops. The tough, resilient nylon pellet forces mating threads together and holds tight. The screw will not work loose.

You save production time when you make products with self-locking UNBRAKOs. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. And in many cases you will save weight and mass by using shorter screws in tapped holes instead of drilling through and using nuts and lockwashers.

Self-locking UNBRAKOs are reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, when screws are properly seated, the locking pellet also functions as a liquid seal.

A complete line of self-locking UNBRAKO socket screw products, in a wide range of standard sizes, materials and finishes, is available through your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

**T.M. Reg. U.S. Pat. Off., The Nylok Corporation*

UNBRAKO SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

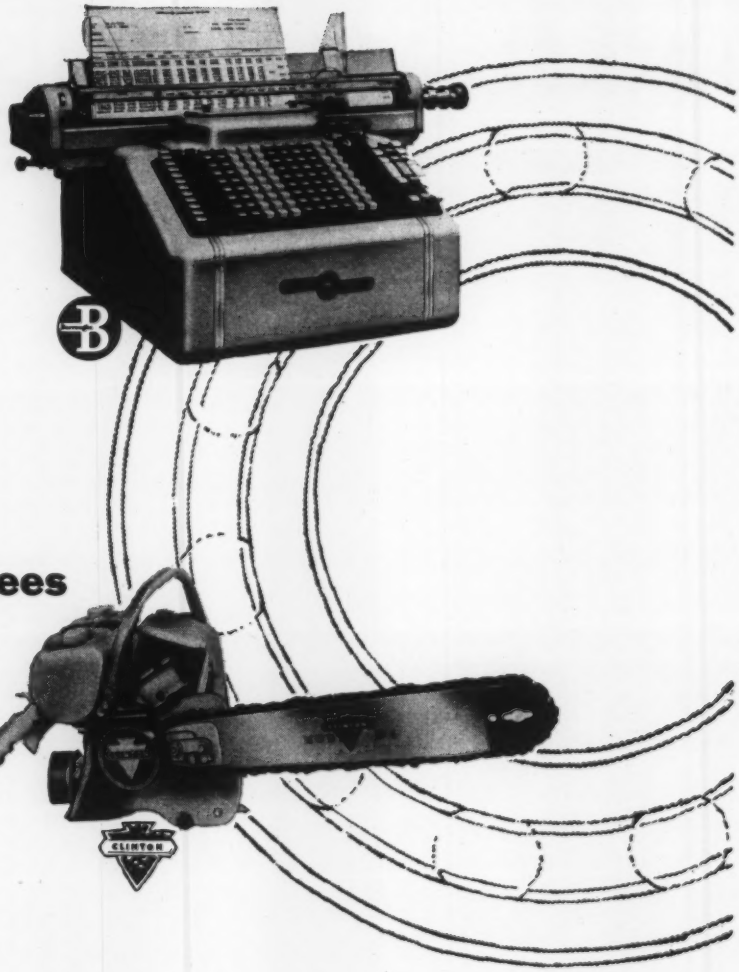
SPS

JENKINTOWN PENNSYLVANIA

Circle 549 on page 19

cutting through accounting costs...

Push a few buttons and the "mechanical brain" of the Burroughs Sensimatic takes over, posting records with amazing speed and accuracy. Smooth, quiet operation is of vital importance. Federal Ball Bearings are used here, too.



...or cutting down trees

Any woodsman becomes a Paul Bunyan with a Clinton Chain Saw. These rugged tools send timber toppling at a furious rate. They've got to be tough—and that goes double for the ball bearings. Clinton specifies Federals.

so much of industry *turns* on FEDERAL ball bearings

Deep in the nation's timberland...high in a skyscraper office building —wherever there's work to be done, you'll find labor saving, time-saving machines. And wherever you find machines, you'll find Federal Ball Bearings, in every size and description, making their vital contribution toward smooth, trouble-free performance. There are 12,000 sizes of Federal Ball Bearings to solve your anti-friction problems. Hundreds of types. Produced by a 50-year-old manufacturer of ball bearings exclusively.

When Federal Ball Bearings are part of so many things you *use*, shouldn't they be part of the things you *make*?

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, N. Y.

New! Ball Bearing and engineering data! 175 pages full in FEDERAL'S NEW CATALOG! To get your copy, just drop us a line.

Federal Ball Bearings *One of America's Largest Ball Bearing Manufacturers*

Circle 550 on page 19

Your customers may need this drive...

TO AUTOMATE YOUR MOTOR DRIVEN PRODUCTS...
GIVE THEM PRECISE, VARIABLE SPEED CONTROL...

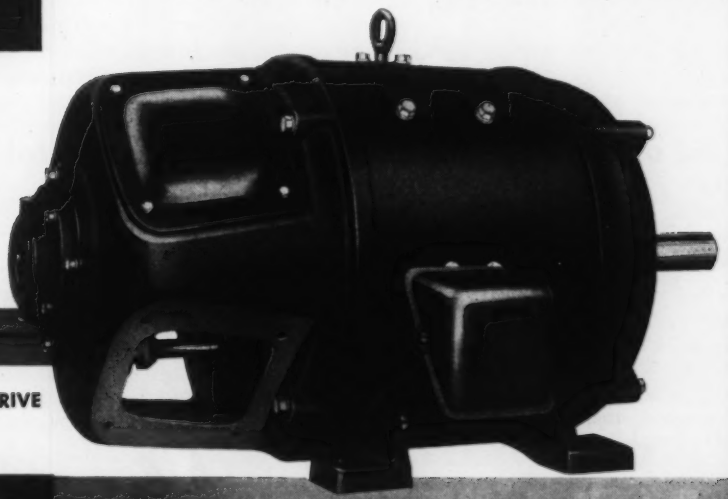
Century Performance-Rated°
SELECTIVE SPEED DRIVE

How many of your customers could use the *full* potential of your product when given automatic operation by a Century Selective Speed Drive? Possibly more than you think.

Here's why. Predetermined, *automatic* manufacturing operations are faster, more accurate than manually controlled operations. A Century Selective Speed Drive on your product will respond to changes in operations—such as varying temperature, pressure, size, viscosity—and *automatically* adjust motor speed to fit the job.

Operating from AC, these drives offer a broad range of DC stepless speed control. They can regulate speed for individual drives or for precision interlocked multi-motor drives . . . can be used for jogging, normal or fast starts and stops, forward or reversing . . . and respond to a wide variety of remote control devices.

Century has more than 50 years' experience in engineering DC motors. For information on any motor application, call or write your nearby Century District Sales Office or Authorized Distributor.



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Performance-Rated ©
MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

Circle 551 on page 19

How's this for corrosion control?

Carpenter Stainless No. 20 pickling rack still in H_2SO_4 service after 5½ years!

Steady exposure to 5-15% sulphuric acid at temperatures up to 200°F for over 5½ years is the service record of this pickling rack made from Carpenter Stainless No. 20. It supports heavy loads of pole line hardware during pickling. Dependable corrosion resistance in the steel is invaluable.

Ordinary steels lasted but a short time on this application. Then, Carpenter Stainless No. 20 was put to work. The result is added safety for the workers, substantial savings in replacements, and uninterrupted production.

Today industry is finding a host of uses for this super corrosion-resisting steel. A wide variety of products of No. 20 can be purchased already fabricated . . . or you can build your own. In addition to hot sulphuric acid, this unique steel resists attack by a long list of other corrosives.

Whatever your corrosive application, talk to Carpenter first about the cost-saving advantages of No. 20. Over 70 years' experience in the development and manufacture of specialty steels are at your service when you contact your nearest Carpenter Mill-Branch Warehouse, Office or Distributor.

Partial list of Stainless No. 20 products now being fabricated:

- Agitating equipment
- Baskets
- Centrifugal pumps and parts
- Coils
  - Heating and cooling
- Dehydrators
- Exchangers, Heat
- Fans
- Fastenings (all types of standard and special design)
- Fittings
- Grommets
- Hangers
- Instruments
  - Heat and temperature
  - Industrial liquid level
- Mixers
- Nozzles
- Pails for sulphuric acid
- Pipe
- Processing equipment (food and chemical industry)
- Pump parts
- Screws
- Tanks, welded
- Thermocouple wells
- Tube
- Valve parts
- Valves
- Vessels, welded
- Weld rods
- Wire
  - Baskets
  - Cloth
  - Stranded
- And others

Carpenter Stainless No. 20-Cb is available from The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, strip, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire.

Our new leaflet *"Positive Protection"* has a more complete list of available products made from No. 20. If you haven't a copy, please drop us a line.

Carpenter STEEL

Super Corrosion-Resistant Stainless

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research

The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.
Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

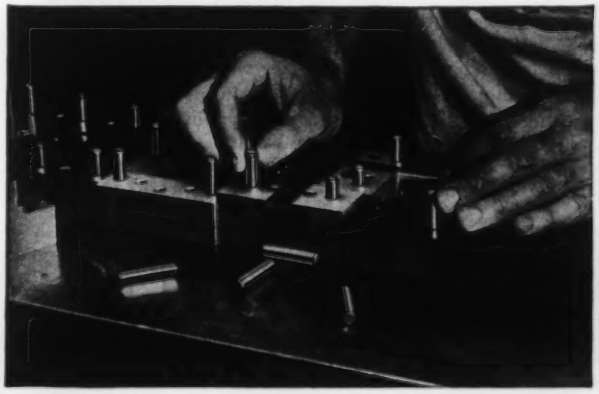
"STOCK ANSWER"
to many a design problem

ALLEN DOWEL PINS

ALLEN DOWEL PINS are being profitably employed in a thousand and one ingenious ways beyond their conventional applications in tool and die work — as economical roller bearings, as axles, precision plugs, hinges and wrist pins to name a few.

If you have an application that will utilize the great strength, accuracy and fine finish of Allen Dowel Pins, you can save substantially on the cost of your product — because you can secure them at favorable prices right from your Allen Distributor's stock.

Check the quick facts at the right and write directly to Allen's Engineering Department for further technical information.



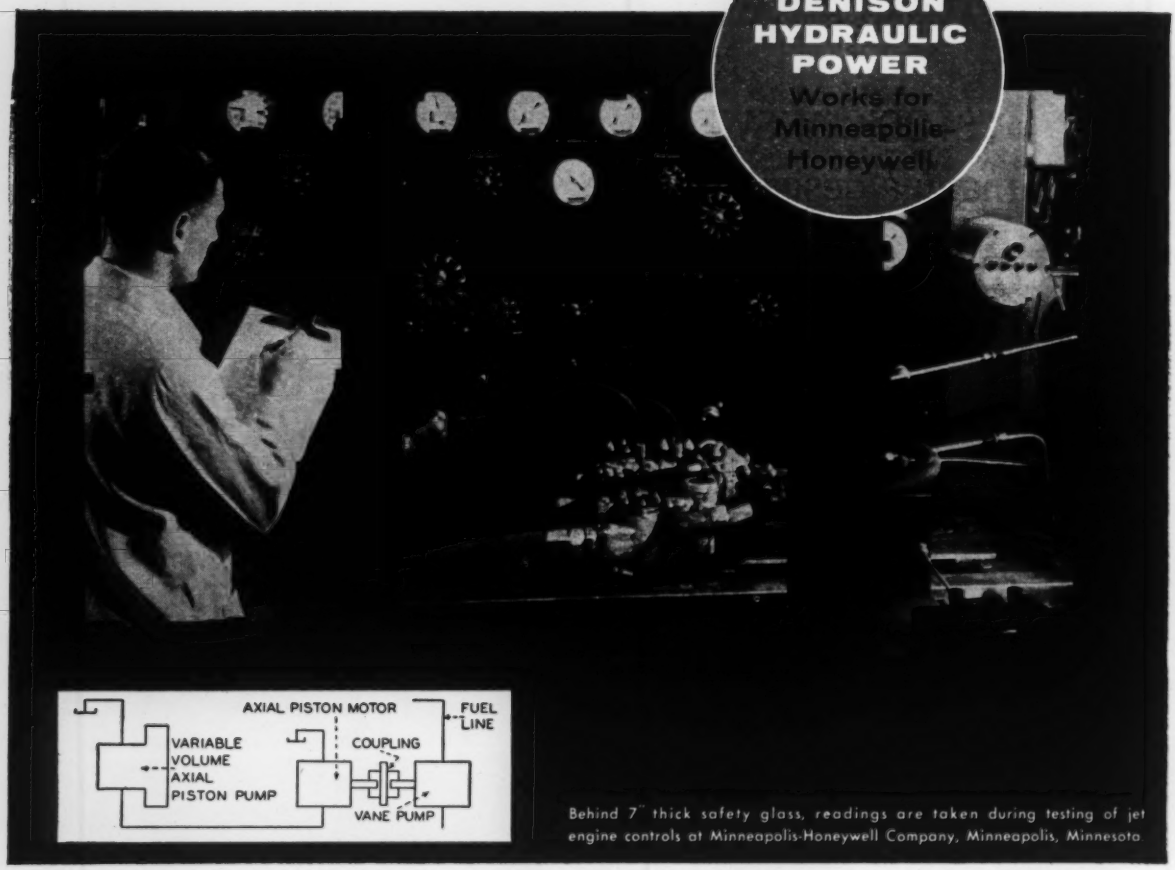
SPECIFICATIONS

- Made from Allenoy heat treated steel. Surface hardness 62-64, Rockwell C scale; core hardness 52-54. Case depth .010" to .020" depending on size.
- Single shear strength 160,000 to 180,000 p.s.i.
- Surfaces precision ground to ± .0001" with micro-inch finish of 6 RMS max.
- Sizes: Diameters, ⅛" to 1". Lengths, ⅜" to 6".
- Two standard oversizes — .0002 for press fits between mating parts, or .001 for repair work, or holes machined oversize.

ALLEN HEAD ALLEN

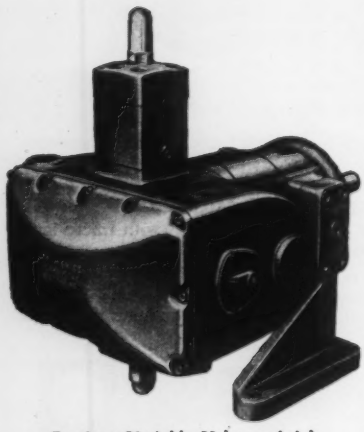
Circle 553 on page 19

How **DENISON HYDRAULIC POWER** Works for Minneapolis-Honeywell



Behind 7" thick safety glass, readings are taken during testing of jet engine controls at Minneapolis-Honeywell Company, Minneapolis, Minnesota

Providing the muscle power for a "ghost" engine



Denison Variable Volume Axial Piston Pump remote controlled.

A unique electronic system developed by Minneapolis-Honeywell to pre-test jet engine controls now eliminates the cost of building and operating a special engine test cell. The system actually produces a more accurate record of performance than would be possible if the actual engine were used.

The system works this way. An analog computer takes the place of the jet engine. Performance data and other characteristics are received from the manufacturer. These are then simulated on the computer and reproduced as electrical signals, which, in turn, run the engine controls.

To provide dependable muscle power for this control system, Minneapolis-Honeywell relies on Denison hydraulic pumps and motors. The key unit, a Denison Variable-Volume Axial Piston Pump is the prime mover for a Denison axial piston motor that in turn powers a Denison vane pump to deliver jet fuel.

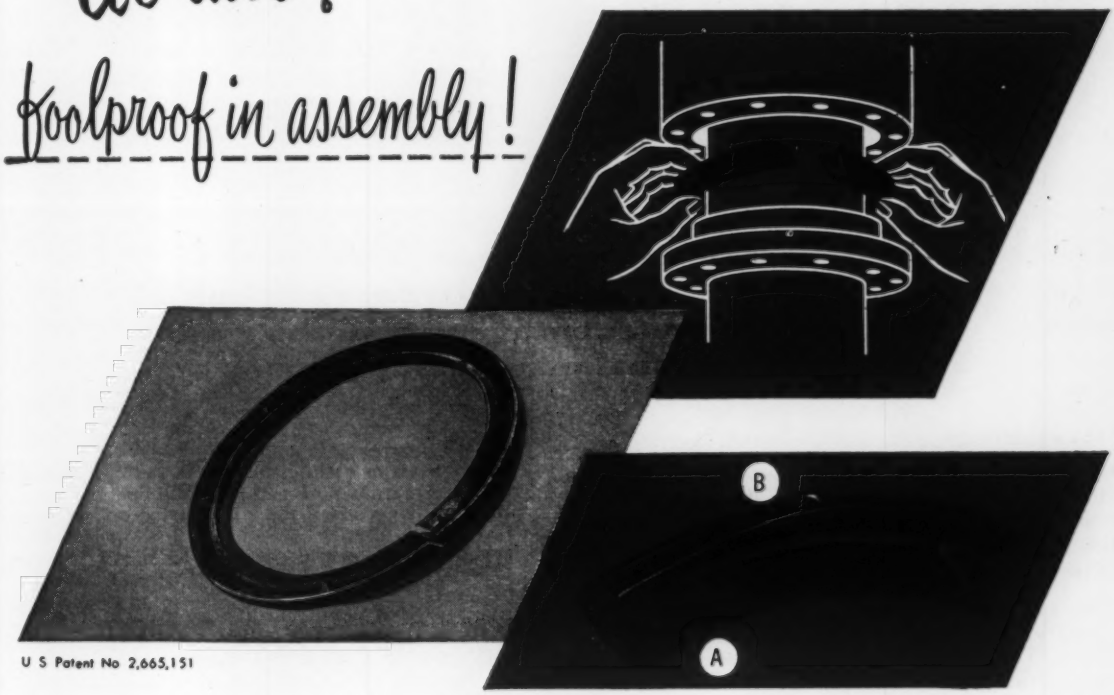
Denison hydraulic equipment is today serving all industries by cutting operating costs, speeding production, and improving reliability. Let a Denison field engineer show you how you can benefit from Denison's hydraulic experience. Write Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

DENISON HydrOILics

Circle 554 on page 19

At last! a really leakproof ring that is foolproof in assembly!



U S Patent No 2,665,151

Linear VEE-DAM rings make other hydraulic packing obsolete

NO OTHER PACKING DESIGN has ever done it! But now LINEAR assures split V-Ring packing that's absolutely leakproof, regardless of the fit at the ring joints!

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LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 555 on page 19

Cylindrical Roller Bearing Inner Races

Their vital importance in bearing performance . . . advantages of carburizing . . . the manufacturing procedures which assure maximum quality and life

The function of an inner race is to provide a fatigue-resistant surface between a shaft and the rollers of an anti-friction bearing. Because of the geometry of a roller bearing, there is a smaller area of contact between the inner race and rollers than there is between the outer race and rollers.

This smaller area of contact has the effect of concentrating the loads on the inner race to a greater degree. Therefore, the inner race is always the critical member of a roller bearing from a fatigue life standpoint. When the inner race is the stationary member and the outer race rotates, this load concentration on the inner race is even more of a factor since the maximum load is repeatedly applied at one point.

Adequate resistance to relative movement between the inner race and shaft is vital to satisfactory performance. HYATT inner races are made of materials chosen to permit relatively heavy press fits. When HYATT press fitting recommendations are followed, the inner race becomes an integral part of the shaft for all practical purposes.

1. WHY CARBURIZING?

HYATT inner races are made of a good *carburizing* grade of steel, rather than through-hardened steel, for several reasons. First, carburizing permits the vital heavy press fits referred to above. Second, tough flanges that will not break out under impact can be obtained on carburized races with no loss of case hardness. Third, carburizing improves load-carrying capacity, as shown in Diagram A. During quenching, the phase change from austenite to martensite which occurs in the outer case is accompanied by a volumetric change; but the low carbon core remains tough and ductile *without* appreciable volumetric change. The result is a tendency to stretch the core and compress the case. Due to the Poisson effect, *the compressive hoop stresses in the external fibres build up the load-carrying capacity of the race.*

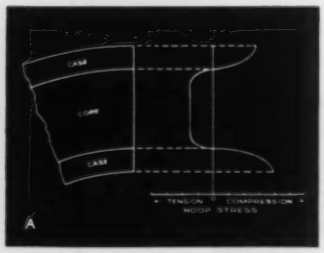
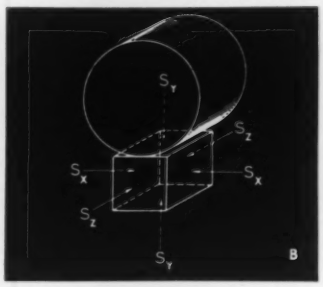


Diagram B shows a typical element of a HYATT carburized inner race under roller load. Stresses in the "Z" direction are negligible. Stresses in the "X" direction are compressive hoop stresses or preload. Stresses in the "Y" direction are compressive stresses due to the load. Without the compressive stress Sx (hoop stress) the load-carrying capacity would be less; and should the stress in the "X" direction become a tensile stress due to pressing a through-hardened race on a solid shaft, the capacity would be still further reduced. Reference to applicable theories of material failure will support this view and indicate why HYATT has gone to substantial added expense to give customers the benefits of carburized inner races.



2. OPERATIONAL REQUIREMENTS

A top-quality inner race should have all the following characteristics:

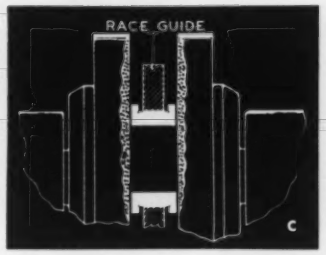
1. *Minimum wall variation:* Concentricity of the inner race pathway to bore is necessary for quiet operation at full bearing capacity.
2. *Minimum runout of race ends to bore:* The bearing must not be cocked on the shaft by location against a square shoulder with a race end having excessive runout.
3. *Minimum runout of race flange inner faces to bore:* Excessive flange face runout results in noisy operation and hunting of the shaft.
4. *Minimum bore tolerance:* An important fitting consideration. If all the available tolerance is taken in the race bore, the shaft tolerance is unnecessarily restrictive.
5. *Minimum pathway and bore taper:* Taper causes uneven roller loading with resultant overheating and poor life.

3. MANUFACTURING PROCEDURES

Good control of primary machining is reflected in good quality of the finished product. The early stages of manufacture, through the heat treating operation, are highly important and are all scrupulously controlled by HYATT. In this article, however, the *finishing operations* are of primary interest and will be discussed in detail.

Centerless grinding operation on a large Hyatt inner race.

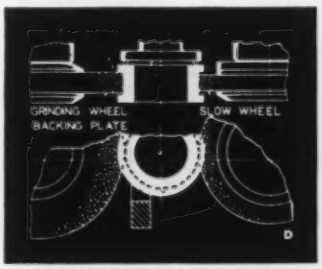
4. DOUBLE END GRIND



The sequence of grinding operations is important. The ends must first be faced off *square and parallel* so that during subsequent operations the ends can be used as accurate reference. The HYATT double end grind operation illustrated in Diagram C insures excellent control of race end parallelism.

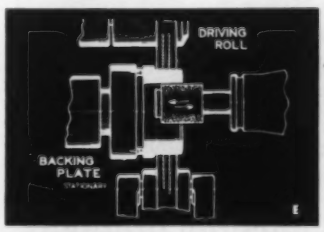
5. CENTERLESS PATHWAY GRIND

The centerless grinding principle was pioneered by HYATT many years ago. This method was a significant improvement over existing chucking methods because it eliminates excessive wall variation introduced by spindle and chucking errors.



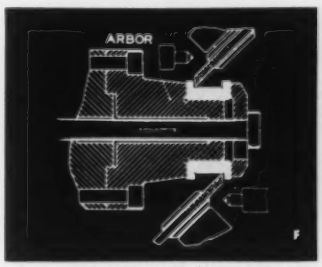
The race pathway is ground by the centerless method to produce a race with as nearly a perfectly round diameter as is commercially practical. Two-point and three-point out of round as well as taper are held to a minimum. Note that the work is rotated with a backing plate against the previously ground end, as shown in Diagram D.

6. CHUCKLESS BORE GRIND



Here again the centerless method is employed to generate an inner diameter (bore) concentric with the outer diameter (pathway.) This is accomplished by driving the race on the outer diameter and positioning the grinding wheel relative to the drive roll. The result is maintenance of minimum wall variation by removing stock from the high spots as they pass between the drive roll and the grinding wheel, as shown in Diagram E.

7. FLANGE GRINDING



All flange faces must be ground to run true with the roller pathway. Since the pathway and bore have been ground using the ends as a reference, the ends are also used as reference while grinding the flange faces (Diagram F). This establishes all-important even contact with the roller ends during operation of the bearing.

8. VIGILANT INSPECTION

Strict inspection is vital to the maintenance of high-quality standards in a precision product such as roller bearings. Working with the finest test equipment under conscientious supervision, highly trained HYATT inspection teams constantly watch the quality of HYATT parts as they are produced. This insures traditional HYATT dependability.

YOU WILL FIND FURTHER DETAILS

in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type of cylindrical roller bearings best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT
ROLLER BEARINGS

Circle 556 on page 19

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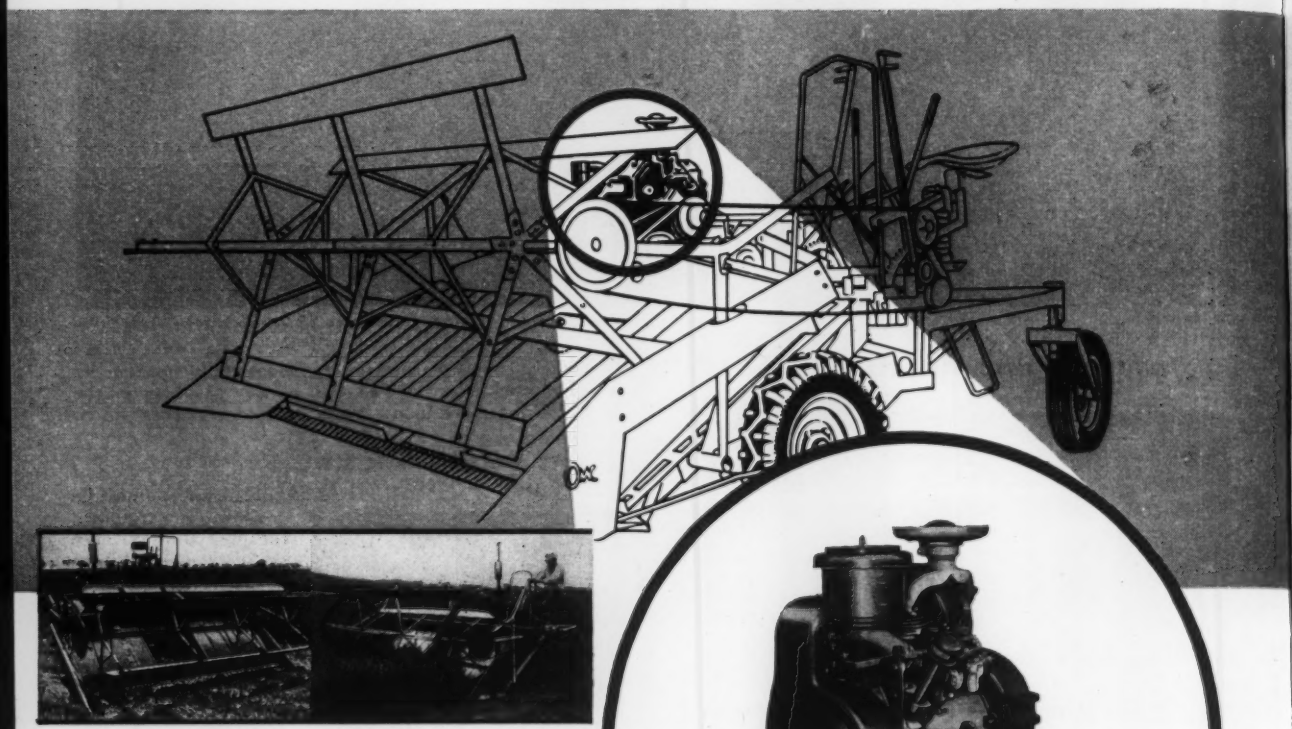
the Self Propelled **WINDROWER!**



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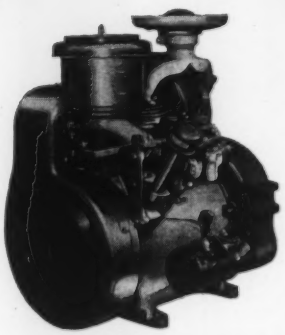
Two of the leading manufacturers of Windrowers, Hesston and Owatonna, realized the advantages that a superior engine would give their unique machines which gather grain and hay with amazing efficiency. That's why both chose the 30 h.p. Lycoming C2-90!



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LYCOMING C2-90
rated 30 h.p.
delivers 30 h.p.!

LOOK AT THESE ADVANTAGES:

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- Highest horsepower and torque per cu. in. displacement in air-cooled field.
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The C2-90 is adaptable to a variety of farm equipment applications from forage harvesters to crop sprayers. And, specifically for farm equipment applications, other larger engines are on the way. To find out how 45 years of engine-building experience can help you, write: Sales Engineering, Industrial Engines, Lycoming, Williamsport, Pa.

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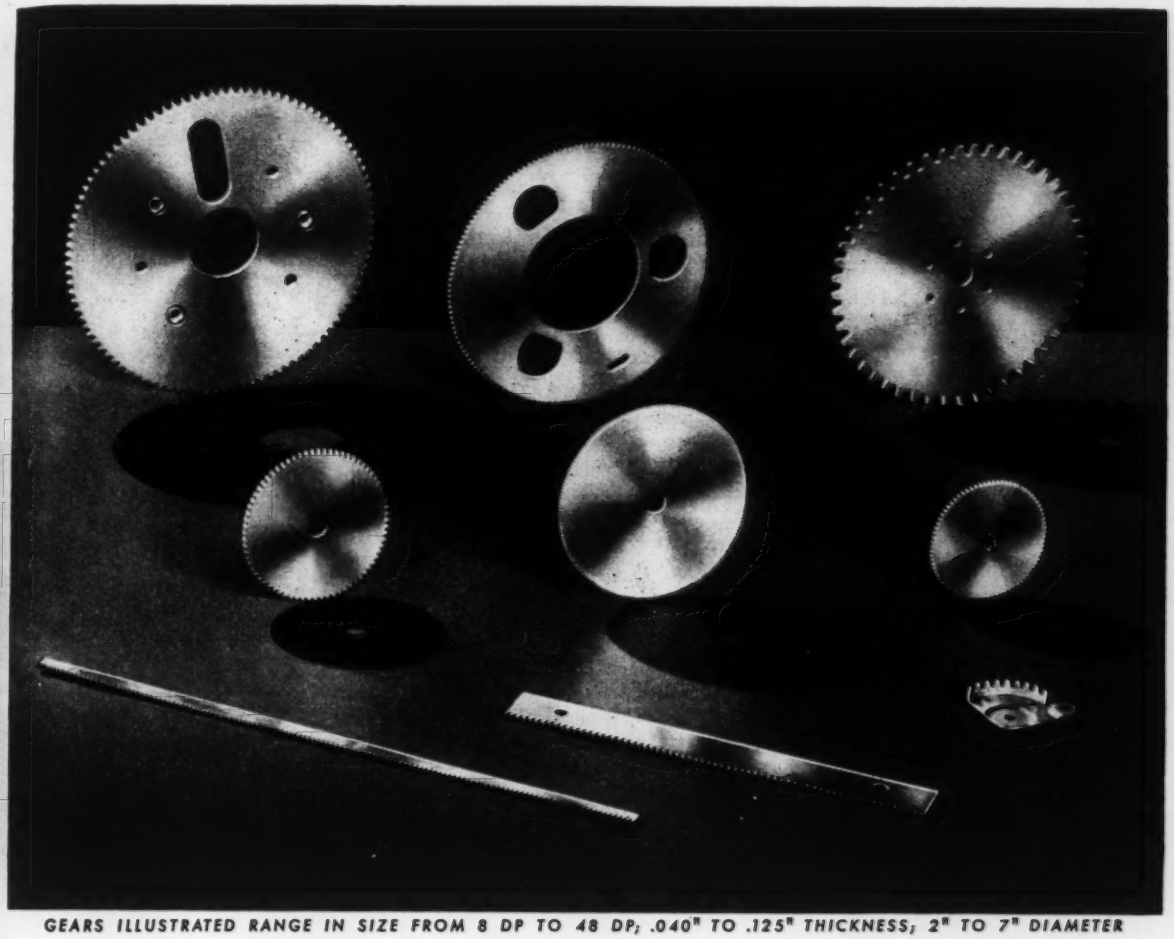
Circle 557 on page 19



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Circle 558 on page 19

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CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***

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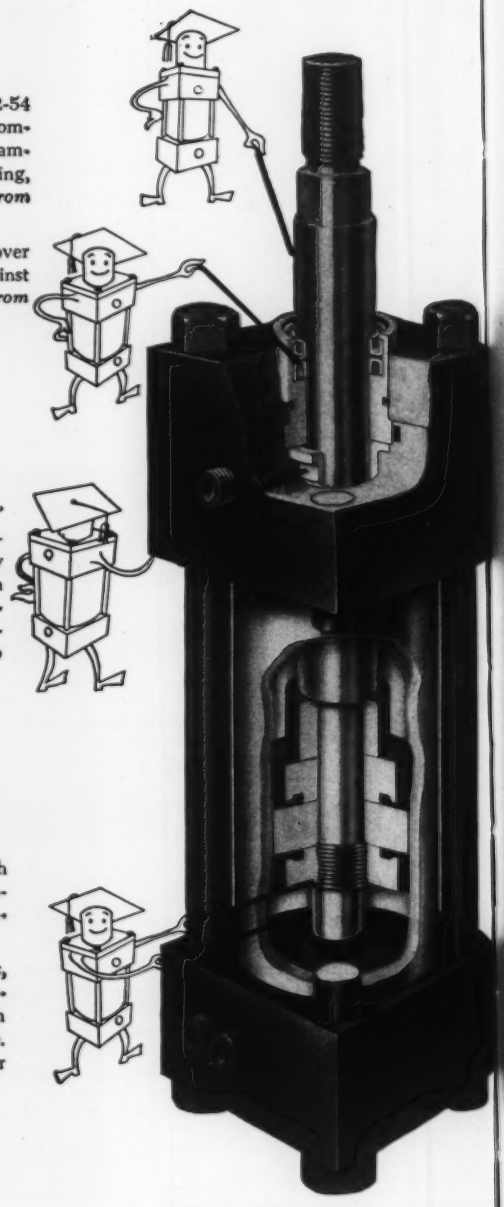

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

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Circle 559 on page 19

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2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

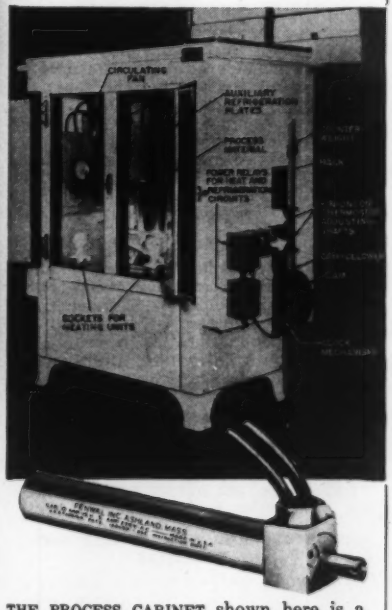
How to Build a Low Cost Program Controller

No. 8 of a Series — *Showing the broad application range of Fenwal Controls*

The problem was to develop an improved method for crystallizing fatty acids. Engineers at Fred S. Carver Inc., New Jersey, needed a means of changing temperatures automatically at various scheduled times during the process, which required temperatures ranging between 130 and 20°F with certain retention periods and closely controlled rate of change between each temperature.

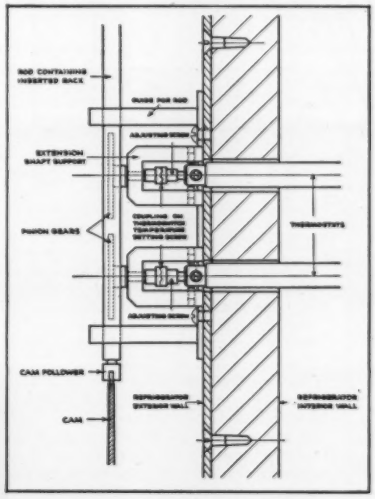
How Fenwal Helped Solve the Problem

The controller was built around two Fenwal THERMOSWITCH® units. One unit to control heating circuits, the other unit to control refrigeration circuits. The programming action is supplied by a rack-and-pinion arrangement. It resets the temperature setting screw of the control THERMOSWITCH unit as directed by an electrically-driven programming cam. The arrangement is used to control test runs to eight days' duration and produces a controlled rate of change of 1°F in four hours.



THE PROCESS CABINET shown here is a modified 18 cu. ft. refrigerator containing auxiliary cooling plates and heating elements. Each circuit is controlled by a cartridge-type THERMOSWITCH unit.

The adjusting screw of the THERMOSWITCH unit used in the process cabinet above is normally ½-in. long. In this application, however, the screw is extended to the outside of the refrigerator wall by a 3/16 in. diameter shaft coupled to the setting screw. A fine-toothed pinion gear (about 10 teeth per inch) is mounted on the end of each extension shaft. The teeth mesh with a rack inserted in a groove in the side of a 5/8-in.



diameter rod. The rod is guided vertically by two bearing blocks on the side of the cabinet. As the rod moves it rotates the pinion gears. This resets the control temperature of the process.

Key to Controlling Rate-of-Change

A cam mounted on the output shaft of an 8-day mechanism controls the position of the rack. The contour of the moving cam programs the process by holding the rack steady to maintain a constant temperature and by moving the rack at a given velocity to change the process temperature at a predetermined rate. *The key to controlling rate-of-change precisely is the fact that a given angular rotation of the adjusting screw of the THERMOSWITCH unit changes its control temperature by a constant, known amount (80°F per 360 angular degrees of rotation).*

Quick Recovery to Desired Control Temperature

Each Fenwal THERMOSWITCH unit controls its 110 volt AC circuit through a series-connected 25 amp relay. Either circuit can be made inoperative by disconnecting a male plug connected to the leads from the THERMOSWITCH unit. When both THERMOSWITCH units are connected, the heating and cooling systems are cycled alternatively to provide quicker recovery to the desired control temperature. The size of heat input is controlled by the capacity of the heating elements used in the heating circuit. To maintain a constant temperature or produce a low rate of rise 50- or 100-watt incandescent bulbs are used. For high rates of rise, some of the bulbs are replaced with 1200-watt resistance — coil heating elements. A circulating fan runs continuously to prevent temperature stratification and eliminate stagnant air that would slow up the response of the THERMOSWITCH units.

Proved Performance at One-Fourth the Cost

The estimated cost of the entire set-up was about $165 — about one-fourth the cost of an equivalent standard controller. And although used over a wide temperature range, there has been no trouble with condensation or moisture, because the electrical contacts of the Fenwal THERMOSWITCH units are sealed inside the cartridge.

Write for new Catalog No. 500 for details and complete product listings on Fenwal Thermoswitch Thermal Controls, including units discussed above, Midget and Miniature versions of these, Snap-Action Controls, and Indicator Controllers.

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Fenwal **CONTROLS TEMPERATURE . . . *PRECISELY***

Circle 560 on page 19

ENGINEERING BULLETIN

ON MICRO-BEARINGS

Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH 1, NEW HAMPSHIRE

Subject: RADIAL AND AXIAL PLAY

This bulletin explains the interrelation between radial play, axial play and contact angle in small instrument type ball bearings, and assists in specifying these characteristics correctly for typical applications.

DEFINITIONS

Radial play is the maximum possible radial displacement of the inner ring with respect to the outer ring when the bearing is unmounted. *Axial play* is the maximum possible axial displacement of the inner ring with respect to the outer ring when the bearing is unmounted. *Contact angle* is defined as the angle between a plane perpendicular to the bearing axis and a line connecting the two points on a given ball where it makes contact with the raceways under a condition of pure thrust load.

Radial play, axial play and contact angle are geometrically interrelated, but since radial play is the most readily measurable, it is the characteristic usually specified.

In *Fig. 1*, values of axial play resulting from a given radial play and ball size, are given for reference purposes.

SPECIFYING RADIAL PLAY

Two fundamental considerations must be established before arriving at a correct radial play specification: (1) the direction of the load imposed on the bearing, and (2) the axial play control, if necessary for the proper functioning of the unit. This is ultimately a problem of considering the contact angle resulting from a given radial play. High radial play is associated with high contact angle. This relationship is illustrated on *Fig. 2*.

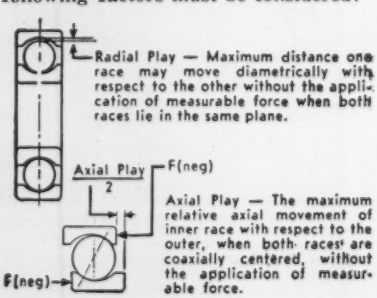
TYPE OF LOAD

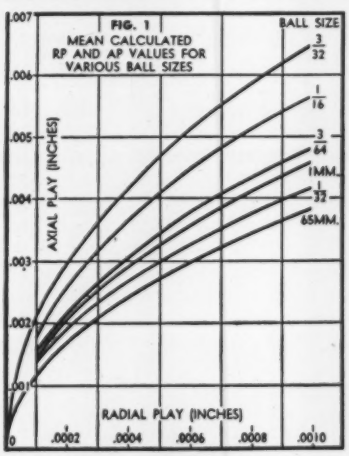
If there is a measurable *axial load*, such as is encountered with bevel gearing, or in an application such as illustrated in *Fig. 3*, the bearings should operate at a high contact angle. Under such circumstances, a radial play of .0005 to .0008 is recommended.

If the application involves a *pure radial load*, such as in the case of spur gears *(Fig. 4)*, there is no concern with contact angle, since it will be zero.

LOW RADIAL PLAY

Functional requirements of the application will dictate whether the radial play is low or standard. However, before *low* radial play is specified, the following factors must be considered:


Radial Play — Maximum distance one race may move diametrically with respect to the other without the application of measurable force when both races lie in the same plane.
Axial Play
F(neg)
2
Axial Play — The maximum relative axial movement of inner race with respect to the outer, when both races are coaxially centered, without the application of measurable force.
F(neg)



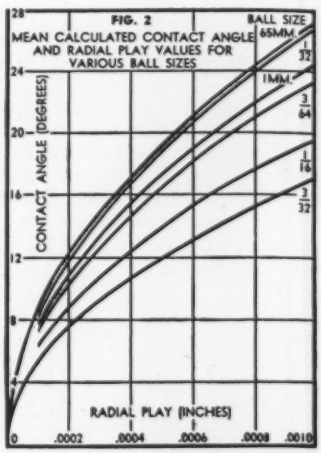


FIG. 5. *Typical Micro-Bearing of the shielded type shown in exploded, cut-away and fully assembled views.*

1. *A bearing with low radial play should not be subjected to interference fitting. This causes reduction in radial play which may create excessive preload resulting in early bearing failure.*
2. *Low radial play results in a low allowable angle of misalignment. An important feature of a ball bearing is its ability to adjust itself internally to possible housing misalignment, particularly when through-boring is not possible.*

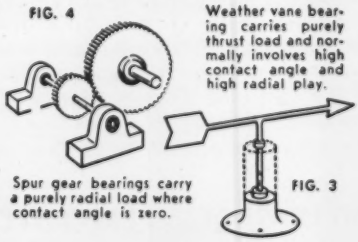
There is one situation, however, where low radial play is recommended. If the bearing is to be subjected to very high repetitious radial shock loads, low radial play minimizes the possibility of bearing damage by distributing the load over a greater number of balls.

AXIAL PLAY CONTROL

If a design calls for axial play values of .002 or less and the bearings are to be used to limit axial travel, it is *not* good practice to achieve this by specifying low radial play. The design should provide for external means of adjustment such as shims. For such cases, the recommended radial play is from .0005 to .0008.

Great care should be exercised if any means other than a calibrated spring is employed to take out *all* axial play. Preloading, with its many complications, may result. Zero axial play automatically yields zero radial play. A high radial play, such as .0005 to .0008, is recommended in cases where axial play is to be reduced to zero by external means.

FIG. 4



Weather vane bearing carries purely thrust load and normally involves high contact angle and high radial play.

Spur gear bearings carry a purely radial load where contact angle is zero.

FIG. 3

RADIAL PLAY SPECIFICATION

There is a misconception among many bearing users that radial play is automatically considered under the ABEC classification. Such is not the case.

However, standard "MICRO" bearings are assembled with a radial play of not less than .0002 nor greater than .0008, unless so ordered. If this range of .0002 to .0008 is acceptable in the application, it is recommended that *No Radial Play Specification* be placed on the bearing.

Radial play is specified most conveniently by a tolerance range. Thus, while the radial play of a given bearing might be .00036, it is more convenient to represent this value as .0002 to .0005. Detailed instructions for specifying other than standard radial play values are incorporated in our catalog.

Since radial play is determined during the bearing manufacturing, specifications of other than standard values should be considered carefully at the design stage, as it may result in delay in assembly and delivery.

DESIGNERS HANDBOOK *OFFERED FREE* TO ENGINEERS

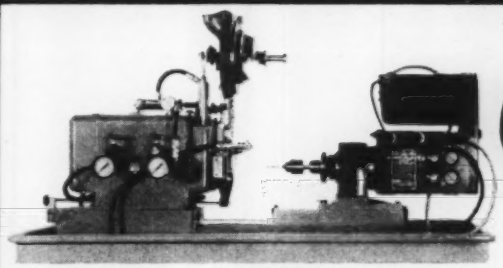
If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in designing instruments or small electro-mechanical assemblies.

It will be sent free to engineers, draftsmen and purchasing agents.

Write: New Hampshire Ball Bearings Inc., Peterborough 1, N. H.

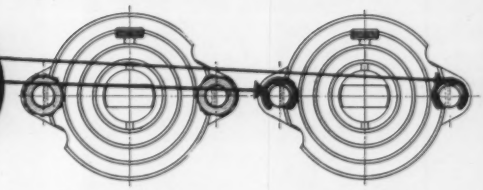
Circle 561 on page 19

Waldes Truarc Retaining Rings Eliminate Machining and Parts—Cut Assembly Time on Drill and Tapper



Beco Model 410 Drill and Tapper

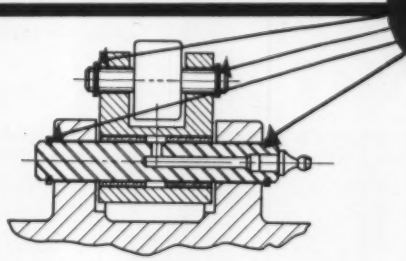
The Batchelder Engineering Co., Inc., Springfield, Vermont uses 4 different sizes of 2 different type Waldes Truarc rings in their new BECO Model 410 Automatic Drill and Tapper. Truarc rings speed assembly, reduce machining, improve design.



ALTERNATE DESIGN TRUARC DESIGN

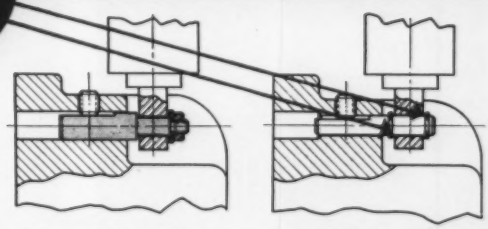
Clamp Cylinder Rod Stop Assembly

Truarc "E" Rings (Series 5133) replace stop nuts in the Clamp Cylinder assembly. They eliminate need for threading 2 rods ...the danger of cross-threading nuts...and costly rejects. Truarc Rings cut assembly time and cost.



Bell Crank Pivot Assembly

Truarc Rings (Series 5100) in Bell Crank Pivot assembly permit grease hole not possible with cotter pin fastener. Use of nuts would have increased machining and assembly costs considerably.



ALTERNATE DESIGN TRUARC DESIGN

Hopper Cylinder Anchor Pin Assembly

2 Truarc Rings (Series 5100) secure and position end of vertical air cylinder. Rings eliminate extra cost of machining 3-diameter pin, threading and undercutting... plus nut and washer. Assembly is quick and sure.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

WALDES

TRUARC®

RETAINING RINGS

WALDES KOHINOOR, INC.
47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

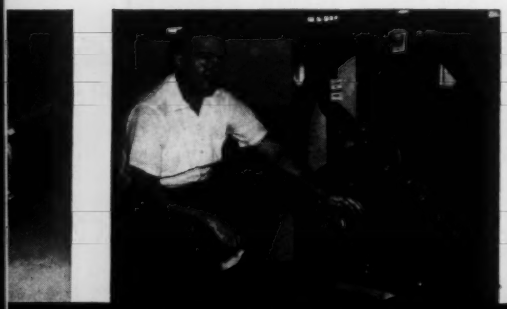
Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name .....
Title .....
Company .....
Business Address .....
City ..... *Zone* ..... *State* .....

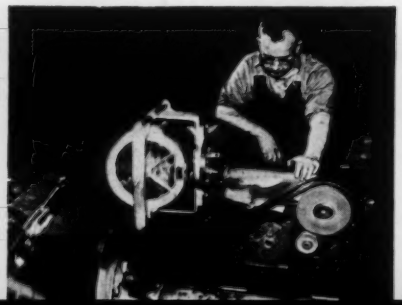
MD 098

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

20 Case Histories of G-E Motor Benefits



AMERICAN COOLAIR CORP.
"customers like 'no-reoiling' feature"



RED DEVIL TOOLS
"stands up under severe vibration"

CAMPBELL-HAUSFELD CO.
"makes product easier to sell"

BUCKEYE INCUBATOR CO.
"customers say 'they're dependable'"

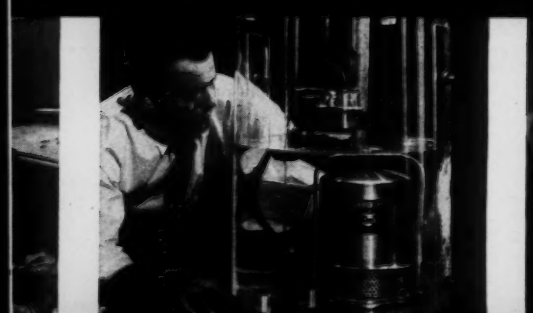
TRUFLOW FAN COMPANY
"never had a motor failure"

UTILITY APPLIANCE CORP.
"virtually trouble-free service"

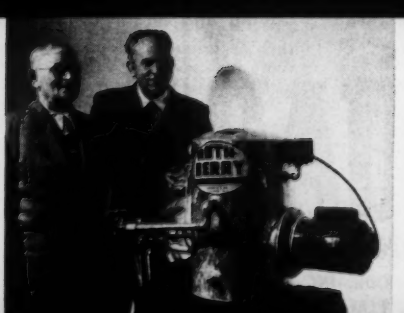
BERKELEY PUMP CO.
"lighter weight, modern appearance"

GENERAL WIRE SPRING CO.
"more than adequate power reserve"

W. M. CISSELL MFG. CO.
"easier to handle and install"

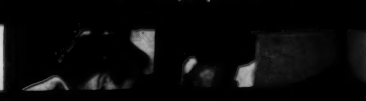


PENBERTHY INJECTOR CO.
"allows maximum design flexibility"



A. P. RUTH & CO., INC.
"speeds assembly, saves on shipping"

PERMUTIT COMPANY
"saved $8 per unit"



—HOW MANY APPLY TO YOU?

METALMASTER CORP.
"wide customer acceptance"

MASTER-BILT REFRIG. MFG. CO.
"standardized 100% with G. E."

AMERICAN DUPLEX CO.
"unexcelled durability"

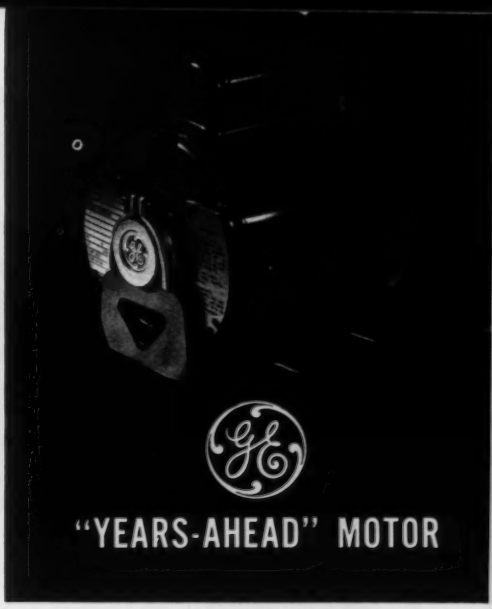
GOLD MEDAL PRODUCTS CO.
"saved 18% in shipping costs"

C. M. SORENSEN CO., INC.
"reduced weight 15%"

ALVEY CONVEYOR MFG. CO.
"all-angle mounting sold us"

MOUNTAIN STATES EQUIP.
"cut weight nearly 10 lbs."

TAIT MANUFACTURING CO.
"neater, more compact"



"YEARS-AHEAD" MOTOR

THESE G-E FHP MOTOR FEATURES ENABLE YOU TO IMPROVE YOUR PRODUCT, YET CUT COSTS

The twenty case histories at left are typical of the profit-building experiences of thousands of manufacturers using General Electric motors. The reason is simple—only G.E. gives you *all* of these outstanding features, combined into a complete line of smaller, lighter motors.

1. SMALLER, LIGHTER DESIGN—The trend to modern appearance and portability is reflected in this General Electric motor. It's 40% smaller, 50% lighter than old-style designs.

2. MYLAR* POLYESTER FILM INSULATION—It has over 35 times more moisture resistance, 8 times more dielectric strength than ordinary paper insulation.

3. ALL-ANGLE OPERATION—General Electric's all-angle lubrication system gives you positive lubrication regardless of mounting position. As a result, you can often avoid the higher cost of "special" motors.

4. EASY CONNECTION—A speed nut welded inside the motor shell permits fast, easy connection of conduit fitting.

5. MOUNTING VERSATILITY—This G-E motor, whether resilient or solid-base, can be rotated inside its cradle to obtain complete mounting versatility. The cradle may also be removed entirely to meet your design needs.

6. DOUBLE LUBRICATION LIFE—The General Electric combination of a larger oil capacity (50% more than old style designs), and an efficient oil retention system means minimum motor maintenance for you.

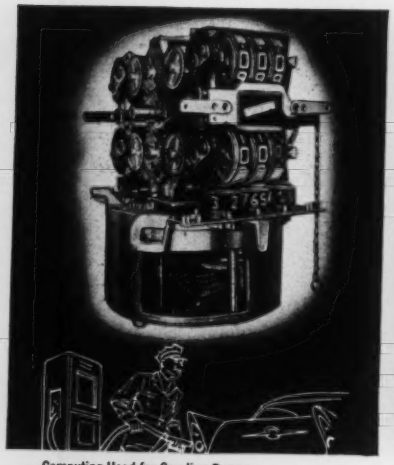
Thousands of manufacturers have already used millions of these "Years-ahead" G-E motors. Why not evalute your own motor savings in terms of these G-E motor benefits?

For more information, contact your nearby G-E Apparatus Sales Office, or write Section 702-29, General Electric Co., Schenectady, New York.

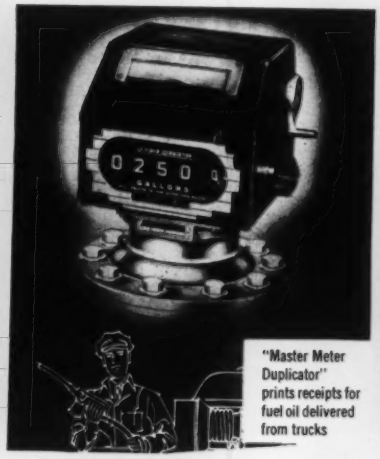
** DuPont registered trademark.*
†Feature of G-E summer cooling fan motors.

GENERAL ELECTRIC

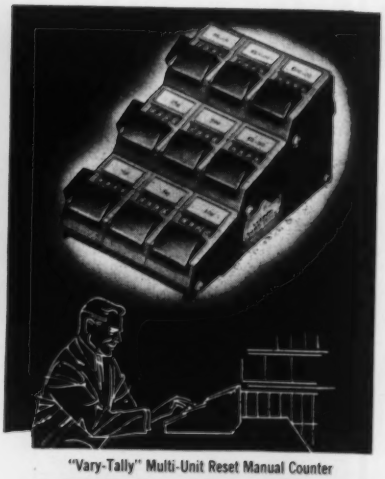
Circle 563 on page 19



Computing Head for Gasoline Pumps

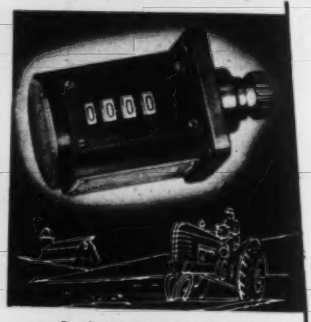


"Master Meter Duplicator" prints receipts for fuel oil delivered from trucks

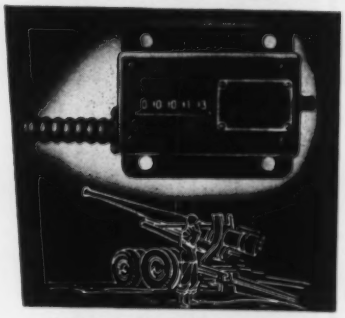


"Vary-Tally" Multi-Unit Reset Manual Counter

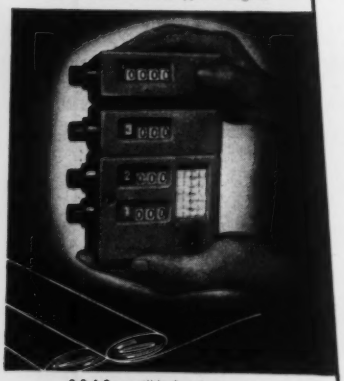
Everyone Can Count on VEEDER-ROOT



Rev-Counter for all types of engines



Recoil Counter for new 280 mm atomic cannon



2-3-4 Convertible Counters (and others) for textile machinery

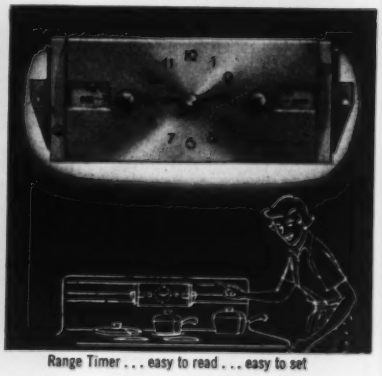
Everywhere you look in everyday life, you see a familiar face . . . the face of a Veeder-Root Counter or Computer. From gasoline pumps to fuel oil trucks to textile mills . . . in the home, on the farm, in business and commerce, in modern automated industry . . . Veeder-Root standard and special devices are keeping everything under *Count*rol . . . manually, mechanically, electrically. And the mathematical probabilities are mighty high that *you* can count on Veeder-Root, too . . . to your advantage and profit. Why not let us figure out how, *right now*?

VEEDER-ROOT INC. • HARTFORD 2, CONN.

Fuel-Remaining Counter for aircraft . . . subtracts as fuel is used

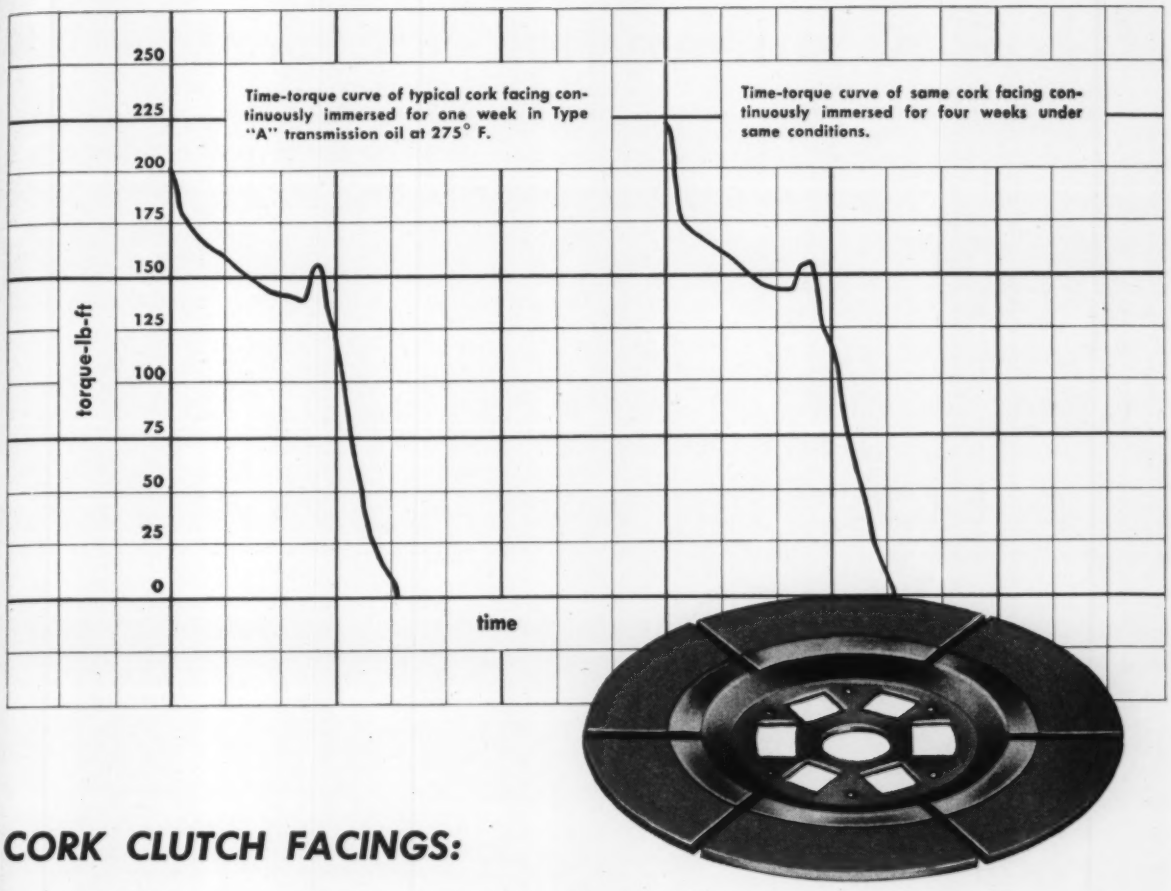
Small Square-Case Counters for office and other machines

Predetermining Counters for preventing short and over-runs on production machines



Range Timer . . . easy to read . . . easy to set

STOCKS OF STANDARD COUNTERS AVAILABLE AT — Greenville, S. C. • Chicago 6, Ill. • New York 19, N. Y. • Los Angeles • San Francisco
Montreal 2, Canada • Offices and Agents in Other Principal Cities



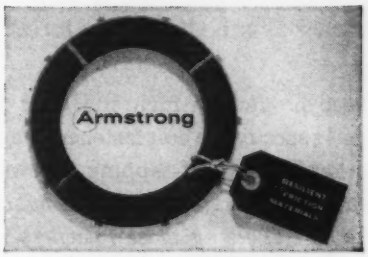
CORK CLUTCH FACINGS:

High torque capacity at up to 300° F. ambient oil temperature

Armstrong resilient friction materials are operating in many wet clutches where the ambient temperatures are in the 250°–300° F. range, almost double the commonly accepted textbook standard. Flash temperatures during engagement actually go much higher without damage to the facing.

Prolonged exposure to hot oil does not affect the torque capacity of a cork facing. This is demonstrated by the curves reproduced above. These show that the torque transmitted at the end of a four-week test period was actually slightly higher than the torque at the beginning.

The upper limits of ambient temperature at which cork facings will operate cannot be fixed accurately since many factors are involved. In some cases, the use of cork facings in "high temperature" transmissions has rather dramatically lowered the operating temperature. This is because cork facings normally slip much less than other materials, thus minimizing one of the main sources of heat and providing cooler operation.

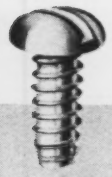


16-PAGE BOOKLET

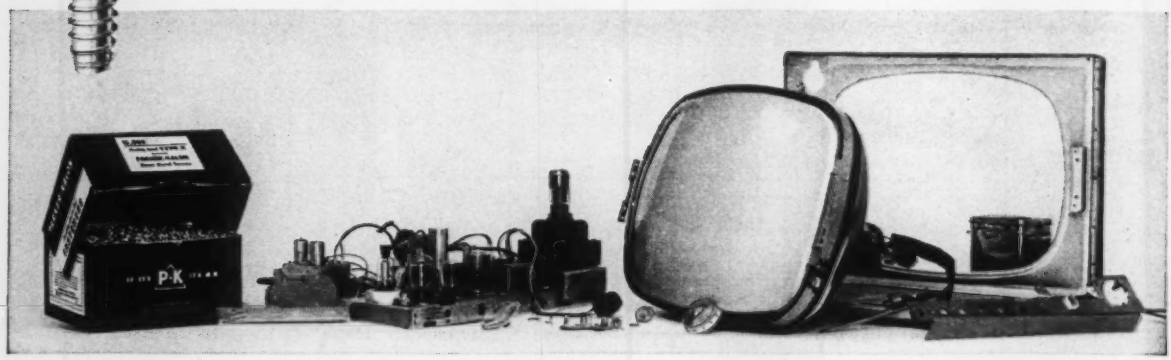
For more information on the design versatility of cork-compound friction materials, send for a copy of our booklet, "Armstrong Resilient Friction Materials." It contains many helpful charts and graphs. Write today to Armstrong Cork Company, Industrial Div., 7209 Dean Street, Lancaster, Pennsylvania.

Armstrong FRICTION MATERIALS

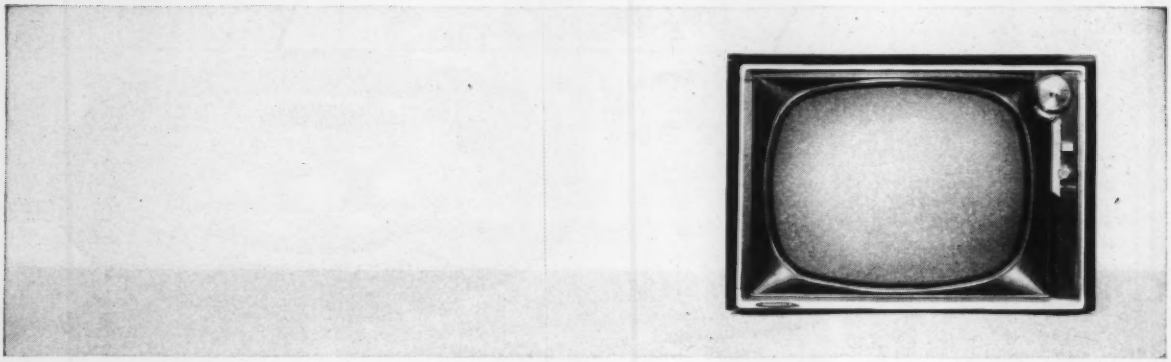
. . . used wherever performance counts



P-K® screws help Motorola



put together assembly savings



How designers and production men work hand in hand to keep production up . . . assembly costs down

To keep production high and costs low, Motorola designers specify the best fasteners that can be bought —Parker-Kalon Self-tapping Screws. They know that *the price paid for fasteners is but a small fraction of the cost of using those fasteners in production.* Because P-K Self-tapping Screws consistently start right . . . drive right . . . and stay tight, Motorola guards against assembly slowdowns and costly salvaging of damaged parts.

This example is typical of thousands of cases where designers help production men turn out a better product *faster*—and at less cost—by specifying P-K Self-tapping Screws. This simple fact is being proved day after day . . . "if it's P-K, it's O.K."

PARKER-KALON DIVISION, General American Transportation Corporation

PARKER-KALON®
fasteners

Sold Everywhere Through Leading Industrial Distributors

Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California

satisfied customers have readymade audiences!

GM GENERAL MOTORS Packard
REG. U.S. PAT. OFF. TRADE MARK

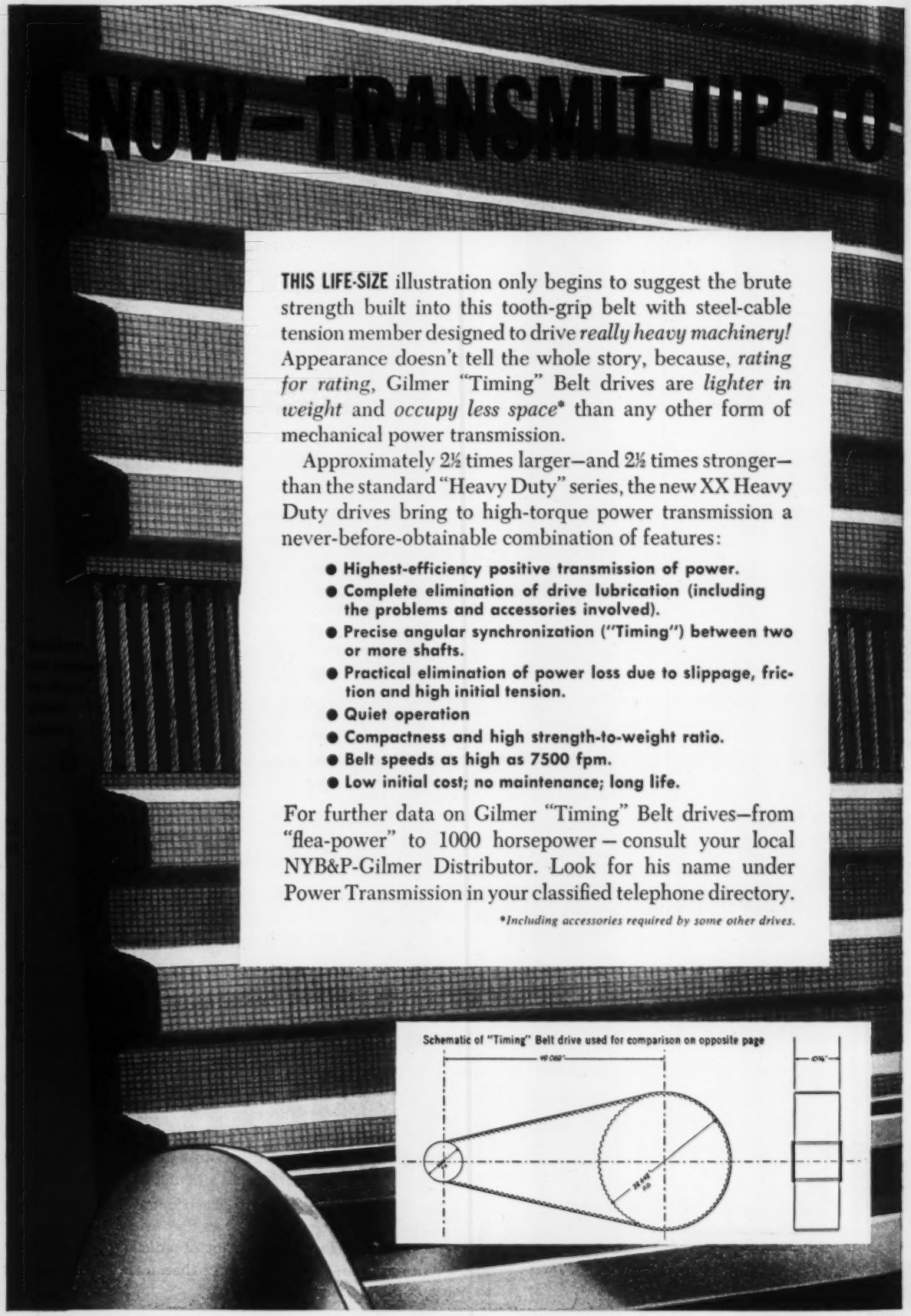
Packard Electric Division
General Motors, Warren, Ohio

Here's a man who is really happy about his new oil furnace . . . an enthusiastic booster who can hardly wait to tell about it. Chances are that a Packard Electric motor has a lot to do with his satisfaction . . . for Packard motors deliver quiet, dependable, long-lasting performance that's bound to please.

For more than 39 years, Packard Electric craftsmen have been building fractional horsepower motors that lead to one customer telling another. Packard builds a lot of satisfaction into every motor . . . and there's nothing better than a satisfied customer to boost both reputation and sales.

Circle 567 on page 19

XUM



THIS LIFE-SIZE illustration only begins to suggest the brute strength built into this tooth-grip belt with steel-cable tension member designed to drive *really heavy machinery!* Appearance doesn't tell the whole story, because, *rating for rating*, Gilmer "Timing" Belt drives are *lighter in weight* and *occupy less space** than any other form of mechanical power transmission.

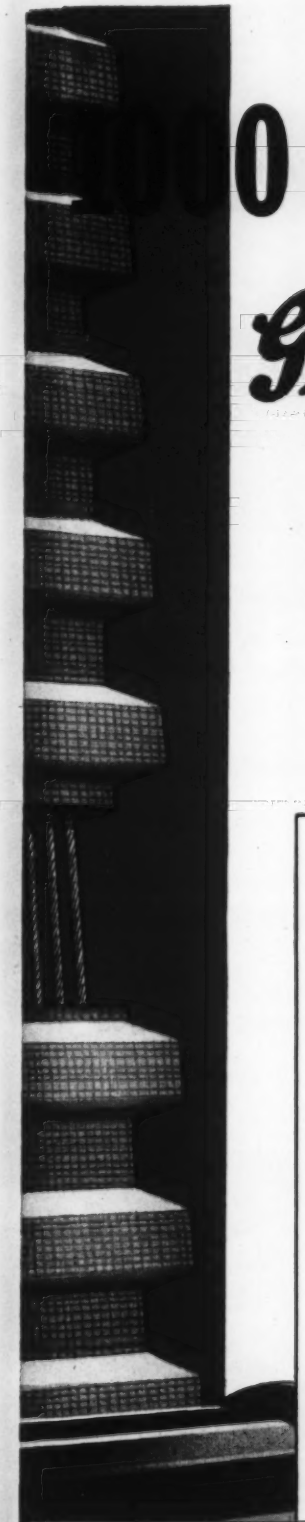
Approximately 2½ times larger—and 2½ times stronger—than the standard "Heavy Duty" series, the new XX Heavy Duty drives bring to high-torque power transmission a never-before-obtainable combination of features:

- **Highest-efficiency positive transmission of power.**
- **Complete elimination of drive lubrication (including the problems and accessories involved).**
- **Precise angular synchronization ("Timing") between two or more shafts.**
- **Practical elimination of power loss due to slippage, friction and high initial tension.**
- **Quiet operation**
- **Compactness and high strength-to-weight ratio.**
- **Belt speeds as high as 7500 fpm.**
- **Low initial cost; no maintenance; long life.**

For further data on Gilmer "Timing" Belt drives—from "flea-power" to 1000 horsepower – consult your local NYB&P-Gilmer Distributor. Look for his name under Power Transmission in your classified telephone directory.

**Including accessories required by some other drives.*

Schematic of "Timing" Belt drive used for comparison on opposite page



0 HP WITH THE NEW *Gilmer* XX HEAVY DUTY 1¼" PITCH "TIMING"® BELT DRIVE

TO HELP YOU COMPARE a Gilmer *XX Heavy Duty* "Timing" Belt drive with the four other common forms of power transmission of equal capacity, a power transmission engineer offers his recommendations based on published application and load ratings, for the following:

A 300-HP drive (at 1160 rpm.) including application factors
3.00: 1 speed reduction
Approximately 50" center distance

Here, complying with minimum pulley sizes and other practices commonly observed, are his recommendations (with approximate comparative cross sections of space occupied by each drive):

"TIMING" BELT DRIVE

Belt: XXH "Timing" Belt 10" wide by 160" P. L.
Motor Pulley: 9.549" P. D. (24-groove) 1¼"-pitch
Driven pulley: 28.648" P. D. (72-groove) 1¼"-pitch
Belt speed: 2900 feet per minute

V-BELT DRIVE

Belts: 10 Super Service "D"-Section V-Belts (DP-225)
Motor pulley: 18.0" P. D. x 10 D-groove, 14¾" wide
Driven pulley: 54.0" P. D. x 10-groove, 14¾" wide
Belt speed: 5380 feet per minute

GEAR DRIVE

Herringbone gear speed reducer with 3:1 ratio. (A typical reducer of required capacity weighs 1440 lb., measures 33" long, 26⅝" high and 19" wide.)

ROLLER CHAIN DRIVE

Chain: #80-8 (8 strands) 1"-pitch x 152 pitches
Motor sprocket: 7.979" P. D. (25 teeth)
Driven sprocket: 23.880" P. D. (75 teeth)
Chain speed: 2380 feet per minute
(Requires Type #3 lubrication with oil-tight case for sump pump)

FLAT BELT DRIVE

Belt: 21" wide x 8-ply x 18' 4" long
Motor pulley: 18" O. D. x 23" wide
Driven pulley: 54" O. D. x 23" wide
Belt speed: 5380 feet per minute

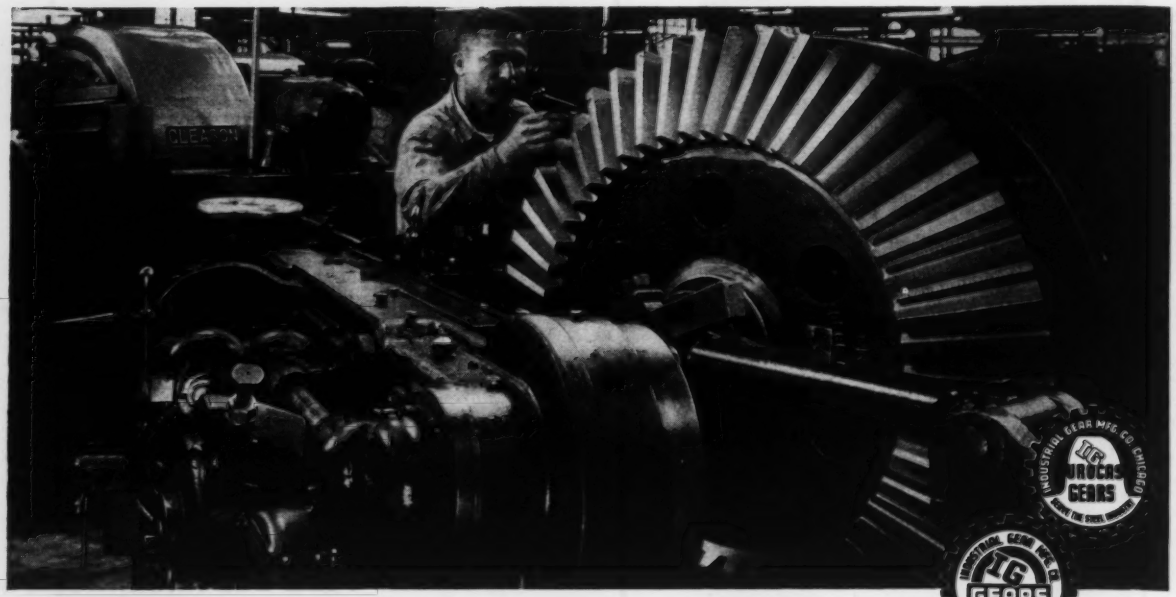
In cost and in weight the "Timing" Belt drive also has a big savings advantage. Ask your NYB&P-Gilmer Distributor for the figures.

NEW YORK BELTING & PACKING CO. Founded 1846

NYB&P

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products



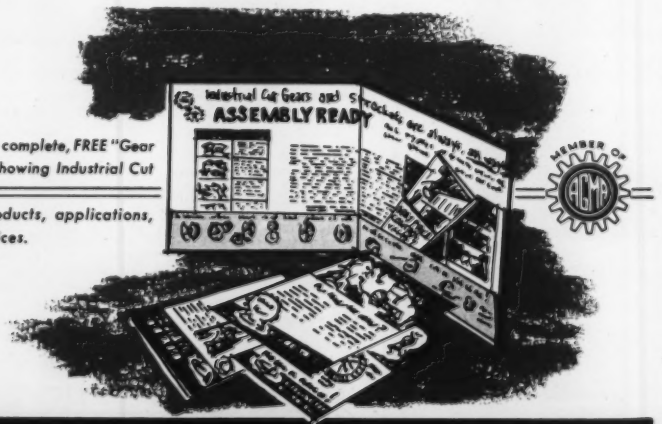
"Closer Dimensional Tolerance"

That's the positive order in every department at Industrial Gear. Whether it be one gear or one thousand—big or little—the tolerances must be held *WITHIN* the limitations of the "specs." The end result (work to be done by the finished gear) must be kept in mind. It is thinking and craftsmanship of this caliber that justifies your confidence in IG to produce cut gears that are always, all-ways Assembly Ready.

This is another reason why IG should become your dependable Gear Department, regardless of the type and quantity of gears you need . . . delivered promptly as you need them.

Meet us at the
IG BOOTHS
405 and **406**
in Cleveland at the
A.I.S.E. show

Write for complete, FREE "Gear Packet" showing Industrial Cut Gear products, applications, and services.



INDUSTRIAL GEAR MFG. CO.
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MACHINE DESIGN
September 20, 1956

$10,000 Clerks

"WE'RE doing too much repetitive clerical and nonengineering work," is the complaint of over 75 per cent of today's engineers in industry, according to a recent survey. Another informal report from one plant of a large company shows that engineers may spend from 20 to 60 per cent of their time on routine production or clerical work.

Engineering management should be gravely concerned about these figures. In effect, they imply that engineering managements are not paying enough attention to efficiency and cost of operation of their departments. Too, they make a mockery of the "shortage of engineers."

No-one asks the president of a company to type his own letters; his time is too valuable. Nor is the treasurer required to personally add up the long columns of figures in his account books; the job can be done far more efficiently by a trained clerk.

Is the situation so different for engineers? Why should costly time of skilled personnel be frittered away on typing letters or memos, performing repetitive computations, or chasing down nontechnical administrative details? Certainly these operations could be handled as well by clerical or nontechnical help—at about half the cost.

The amount of routine nonengineering job detail is a sore point with engineers—listed as a complaint more than twice as often as pay in the previously mentioned survey. It can cause dissatisfaction—and perhaps be a contributing cause for a man to leave his job. What then?

It costs $2000 to $3000 to recruit and hire a replacement, not to mention the cost of training (which some say can run upwards of $10,000) and the disruption of job reassignments. This is a "hidden" cost worth considering.

From both standpoints—the engineer's and his management's—it certainly seems that adequate stenographic, clerical, computational and administrative services should be provided. No engineer should ever have cause to repeat the comment of one disgruntled man, "What am I—an engineer or a $10,000 clerk!"

Robert L. Stedfeld

ASSOCIATE MANAGING EDITOR

The strategic role of

Engineering Management

ALMOST fifty years ago a mechanical engineer, Fredrick W. Taylor, delivering a commencement address at Purdue University, remarked that an engineer was a man who could produce a part for $1 that anyone else could produce for $2.

Corporation leadership has recognized this fact and engineering today occupies a strategic command post in industry. Accelerated industrial activity has expanded engineering management's role and its responsibilities.

Engineering management's job is highlighted by three major developments appearing in the forefront of the panorama presented by contemporary industrial activities.

Responsibility for Products

First, consumers have demanded new and better products. Coupled to this demand, competition has placed a premium on lower costs. Each of these is a primary responsibility of the engineering department.

Engineering should assume full responsibility for the corporation's products. Engineers should be looked to for counsel before any decisions are made touching upon product programs. Engineering counsel must be incorporated wisely with counsel from distribution, production, legal and financial divisions in the interests of successful programs that will be productive of new and better products at lower costs.

Responsibility for Weapons Systems

A second major engineering responsibility is that of our security as a nation. Much more important to all of us in the long run than the material comforts which the engineer provides is the security of our American way of living. The responsibility for the preservation of this security rests squarely on the shoulders of the engineers of this country.

Such weapons systems as our guided missiles with their atomic warheads and closely allied radar for search, warning, tracking and guidance have been made possible by engineering genius. Unfortunately one can't be sure that one is in a position to tell the engineer what is needed. One can only tell the engineer to reach into the unknown and bring back as much, and as soon, of the best he can develop. This much is certain—the enemy, whoever he may turn out to be, is working on this same assignment. The key to national security is sound engineering management.

Responsibility for Effective Utilization of Engineering Resources

A third responsibility of engineering management stems from the current scarcity of engineers —a scarcity that can't be corrected within any short period of time. Through sound engineering management we must make effective use of available engineering manpower.

A look at statistics reveals that there are in this country approximately 500,000 engineers at the present time. Some 100,000 of these engineers are engaged in research and development activities. Additional manpower is anticipated at the following rate:

1957	34,000	1961	39,000
1958	37,000	1962	39,000
1959	37,000	1963	40,000
1960	38,000	1964	43,000

There is every indication that the shortage of engineers will continue for a long time if industry's demands are realistic. It's hard to get accurate estimates of the number needed but some feel that a conservative figure for current requirements would represent a doubling of the present supply.

Since 1939 the productive capacity of this country has increased 325 per cent. In the next 10 years a further increase of 35 per cent is expected. Industries won't share equally in this growth, but most should experience an expansion. Durable and nondurable goods producers may increase their overall sales an estimated 40 per cent. Service activities may increase 30 per cent. This continued expansion represents an increased demand for engineering talent.

There is no question that more engineers can be used in our businesses, and more engineering resources can be devoted to work on military programs. The latter is a necessity.

Authoritative sources indicate that in 1954 Russia had more than 540,000 engineers. In that year

By Philip Marvin
American Management Association
New York

Russia graduated 53,000 engineers in sharp contrast to our output of 22,000 engineers. Some argue the issue of quality vs. quantity in defense, a valid argument only if its premise is valid.

The only immediate practical solution to soften the impact of this shortage is the application of the best possible management to our existing engineering resources. A high level of engineering management must be substituted to counterbalance the current shortage of engineers, until such time as this condition can be remedied.

A Broad Responsibility

The engineer makes possible our American way of life. Our homes, automobiles, highways, public transportation systems and vitally essential public services such as gas, electricity and the telephone are all products of engineering skills.

The research worker in the basic sciences uncovers new principles, but until the engineer takes hold of these, they are mere laboratory curiosities.

The speed with which we can raise our standard of living is in direct proportion to our ability to effectively utilize engineering manpower. Sound engineering management is the key to the effective utilization of manpower.

Know-How is Based on Experience

Most engineering managers, at one time or another, have expressed the wish that more of the facets of engineering management were settled with definiteness. Unfortunately, engineering management is in a state of flux. The process is one of evolution and indicates progress. This fact alone is encouraging.

All that is known about engineering management has been learned from the actual working out of engineering management practices on the actual firing line of daily experience.

Each year more is known about engineering management. Each year witnesses a better job of applying scientific principles to the solution of problems of everyday living. But management practices should be carefully scrutinized periodically. Those that haven't done the job should be scrapped. The problem remaining should be restudied. Action should be taken in the light of the best available knowledge. There is no end in sight to this process.

By a process of selective sifting, worthwhile management practices can be highlighted for fur-

Table 1—Basic Administration Functions

1. Clearly stated goals should be established.
2. Engineering functions should be balanced against goals.
3. Engineering standards should be mutually agreed upon by top management and the engineering group.
4. Strong leadership should be available.
5. Policies should govern operations.
6. Engineering tools should be available.
7. Resources must be organized for performance.
8. Functions must be adequately manned.
9. Corporation interests must come before personal interests.
10. Planning should precede action.
11. Operating controls should be functioning.
12. Operations should be researched.

Table 2—The Mileposts of Product Development

1. Creative development
2. Preliminary screening
3. Patent search
4. Preliminary technical-economic survey
5. Literature search
6. Final screening
7. Project scheduling
8. Development of preliminary technical-economic survey
9. Research
10. Development
11. Engineering
12. Management review and approval of pilot run
13. Design review
14. Prototype model development
15. Engineering tests
16. Field tests
17. Review of test data
18. Redesign
19. Production review and redesign
20. Final model development
21. Preliminary production analysis
22. Selection of parts to be manufactured
23. Selection of parts to be purchased
24. Realistic cost analysis
25. Pilot run
26. Initial market test
27. Management review and approval of production release
28. Service organization
29. Distribution organization
30. Installation of general sales organization
31. Production tooling
32. Production
33. Bread-and-butter production and distribution

ther scrutiny. Practices others have uncovered in their daily work can be studied. Individual contributions based on first-hand experience with management problems add to the store of knowledge.

Four Goals for Engineering Management

Engineering management efforts directed toward four specific goals offer rewarding returns in increased engineering productivity. These four goals commanding the attention of engineering administrators who are in positions of responsibility today in growth corporations are:

1. Development of improved human relations in the engineering division.
2. Integration of the basic elements of a balanced engineering operation.
3. Injection of engineering counsel at all management levels.
4. Initiation of comprehensive product programs.

A Basic Human Relations Problem

The moment we talk of management we enter the realm of human beings and human relations. There isn't any single aspect of business operations which is less mechanical or less subject to formula than its management aspects.

It must be recognized at the outset that engineering management poses some severe problems because it deals in sharp contrasts. It deals on one hand with the human element and on the other hand with the inanimate nature of the engineer's activity in the exacting environment of the physical sciences.

By contrast, the manager of a sales force deals with individuals whose own daily activities are closely tied to the human equation. The salesman, usually an extrovert, is accustomed to dealing with people and accepts the "give and take" aspect of team activities. On the other hand, the engineer is inclined to be an individualist both by nature and the requirements of his job. This accentuates management's problems. Notwithstanding, an effective management job can and must be accomplished.

The success of technical activities today calls for a curiously complex combination of individual effort and group effort. As a general rule individuals fit either the category of the group worker or individual worker. It is rare that an individual fits into both categories.

Effective engineering work on projects of the magnitude encountered today must in its final form depend on group efforts. At the same time the basic creative work is accomplished by the individual. Management's job is to find a way of stimulating team play without sacrificing all-important individuality.

Management must call into play educational, organizational and operational techniques. Already results have been achieved in specific instances which are so encouraging that little question remains that the desired end results can be achieved. These cases are too few to serve as a basis for sound guidance as yet. They do serve to indicate that management can preserve the individuality of its engineers while integrating their efforts in group undertakings. New ideas and engineering management concepts must be developed and tested before this goal will be reached.

Table 3—Responsibilities of Engineering

1. Take the initiative in injecting engineering counsel into corporate affairs broadly in areas of
   - Research
   - Production
   - Market analysis
   - Sales
   - Finance
2. Adopt a policy of look, see, act vs. rationalize, comment, talk!
3. Lead management thinking in product areas. Profits are based on products. Products are an engineering responsibility.
4. Counsel management action—diversification, merger, consolidation, and product line decisions rest ultimately on engineering facts.
5. Exercise adaptability and develop an understanding of finance, distribution and other areas of broad management significance.
6. Promote the personal development of the individual engineers in the corporate environment by counsel and carefully established policies.
7. Integrate engineering activities for effective and economical operation.
8. Initiate comprehensive programming procedures and policies and set programs into action.

A Problem of Integration

The engineering manager's task is one of combining a number of management functions in such a way that he will produce the maximum in the way of results. Often the reason underlying the failure of a particular undertaking is directly traceable to accidental neglect of one or more functions. Almost any administrative assignment can be broken down into the twelve basic functions listed in Table 1.

Skillful administration is based not alone on recognition of these functions, but in addition on the willingness to keep them in mind at all times in making administrative decisions.

Counsel Should be Far-Reaching

With our growing and complex industrial technology, it becomes increasingly important that our engineering administrator shoulder two broad responsibilities. First, the administrative responsibilities of his own divisional and departmental activities and, second, counselling responsibilities with respect to certain technical phases of operations of other divisional and departmental activities. This should be vigorously pursued to the degree necessary for effective action in guiding sound product programs. In furthering the soundness of product and engineering programs, engineering administrators should take an active interest in developments bearing on:

1. Corporate organization.
2. Fiscal policies.
3. Distribution programs.
4. Manufacturing planning.
5. Research and development.
6. Long-range programming.

In each of these areas, engineering counsel should be available in order that product programs can be adequately integrated. Maximum engineering effectiveness can only be achieved when engineering management plays an active role in the top management of the enterprise. This requires a real selling job and presents a great challenge to the engineering administrator.

Comprehensive Programming Essential

One of the inherent problems of management men is the nervous wear and tear that results from our inherent dislike of laying out a long-term pattern of achievement with subsidiary objectives marked all along the way. Results are attained in an orderly manner by executing a carefully thought out and integrated plan of action. Human nature, and that's all of us, seems to prefer to rely on instinct and improvisation, on hunch and insight as needs arise and circumstances warrant. How many times have we encountered the phrase, "We'll cross that bridge when we come to it." This human reaction is a great hazard when it comes to actually sitting down and formulating just exactly what you want to accomplish and when you want to accomplish it.

Engineering programs that produce profitable results are themselves the product of careful and systematic planning. Engineering managers who recognize the mileposts in planning are usually rewarded with successful results.

Programming requirements vary from corporation to corporation, but essential characteristics are fundamental to all programs. Basic product concepts should be screened. The more promising ideas should be the subject of further research and development. Developments that pass the tests of feasibility and potential profitability should pass to pilot development and pilot production stages and then on to manufacture and sale. In all some 33 steps are involved. Each step in Table 2 is a milepost of more than passing importance to engineering administrators.

These mileposts present a challenge to engineering administrators. Part of the challenge centers around the planning function itself, but the overall challenge goes beyond. Recognition of these mileposts forces engineering administrators to inject engineering counsel throughout the length and breadth of the course of product development activities—from the creative development phase to the final phase wherein the product is placed in the hands of a satisfied customer.

The Responsibilities of Engineering Management

Engineers must broaden their sphere of influence. The rapid advance of technology demands that the engineer enlarge the role he plays in corporate management. In accepting this challenge the engineer must accept the responsibilities outlined in Table 3.

Dynamic engineering management implies not only administration of the engineering division or department, but aggressive counsel in all management functions to permit engineering and corporate operations to achieve maximum effectiveness and profitability.

Tips and Techniques

Paper Clip Lettering Guide

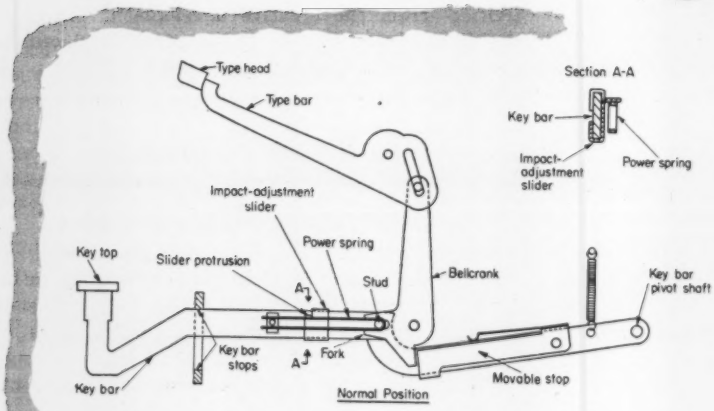
An ordinary paper clip may be used as a lettering guide by placing the tips of the index and middle fingers on the ends of the clip and using

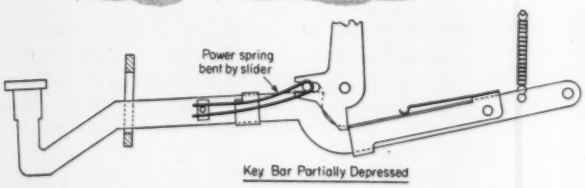
BY PLACING THE TIP OF THE MIDDLE FINGER AND INDEX FINGER ON A STANDARD PAPER CLIP AND USING

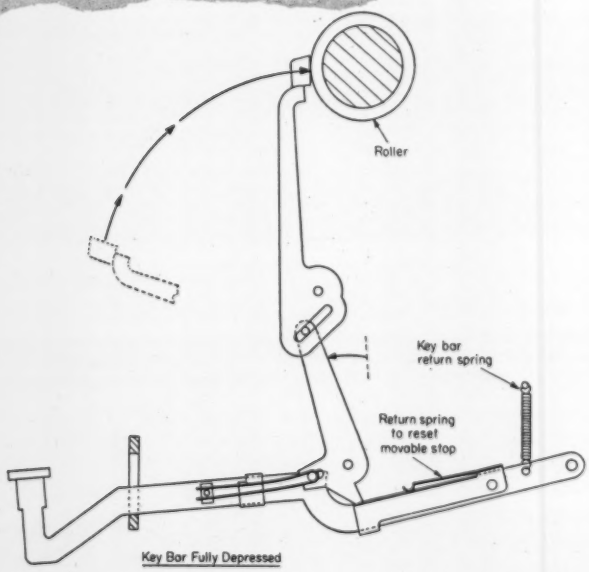
the edge of the clip as a pencil guide. Curves and horizontal lines are added freehand.—MERTON O. HODGES, *General Electric Co., Lynn, Mass.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

scanning the field for *Ideas*



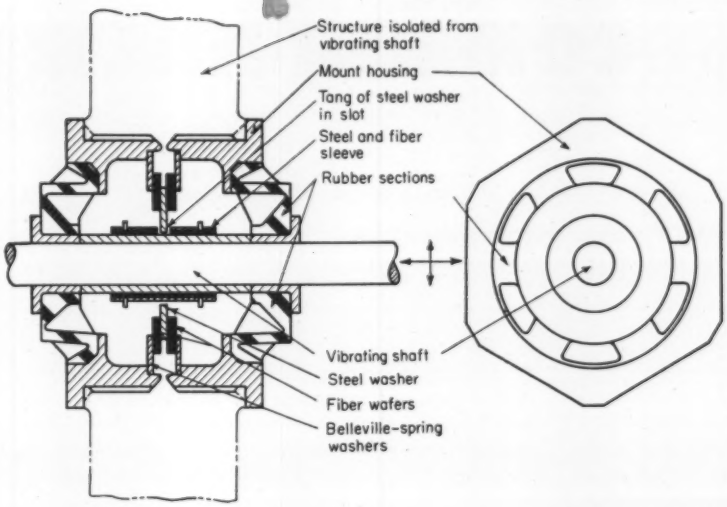




CONSTANT FORCE ACTION is maintained under varying input conditions by a novel spring-linkage system. Developed in several forms by Waldemar Ayres of Ft. Lauderdale, Fla. and covered by patents pending in this country and abroad, the mechanical system has been designed for application on manual typewriters to produce uniform type impressions regardless of variations in "touch" on the keys.

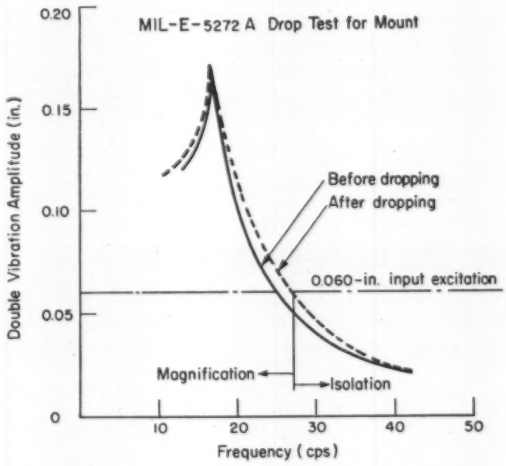
In this design the key bar is linked by means of a power spring to the bellcrank which drives the type bar. A slider on the key bar bends the power spring when the key bar is depressed. A movable stop carried down by the key arm restrains the bellcrank until the corner of the stop clears the lower tip of the bellcrank. At this point the power spring drives the bellcrank fork downward rotating the bellcrank counterclockwise and the type bar clockwise. Impact force of type head against roller is controlled by the position of the impact-adjustment slider which varies stiffness of spring action.

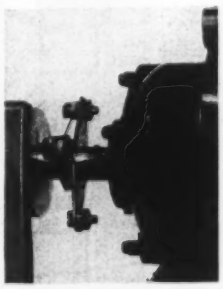
The power spring returns the bellcrank and type bar to their initial position when pressure on key bar is released. A spring on the movable stop automatically resets it.

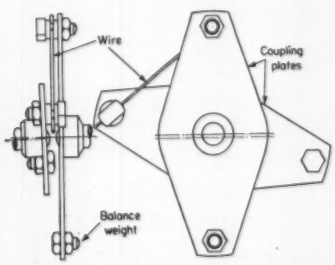


TWO - DIRECTIONAL FRICTION DAMPING controls low-frequency resonances in a vibration mount designed to also provide high-frequency isolation. Reported by W. W. Jarowey of MB Mfg. Co., division of Textron American Inc., the mount assembly incorporates shaped-rubber elements in each end of a gland construction to isolate high-frequency shaft vibrations. Inside the housing between the rubber elements is a combination steel-and-fiber slotted sleeve pressed down on the shaft circumferentially by snap rings. The sleeve is restricted from free axial movement by a tang on a steel washer which is held between fiber washers. Force necessary to slide the tanged washer is controlled through Belleville-spring washers which are fixed to the mount housing and clamped down on the fiber washers.

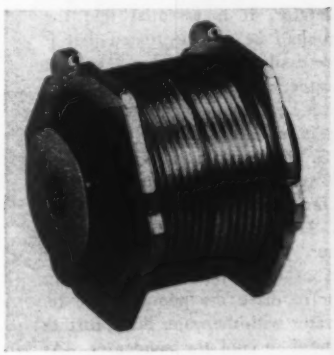
Axial and radial clearances between the sleeve and tanged washer permit small shaft excursions, which are characteristic of high-frequency vibration, without sliding the sleeve axially or the washer radially. If axial excursions of the shaft exceed these clearances, the tang of the steel washer bears axially against the sides of the sleeve slot introducing axial dry-friction damping. Likewise, if radial vibrations of the shaft develop that are greater than clearances allow, the steel washer is forced to slide radially between the fiber washers and dry-friction damping is provided in that plane.







FLEXIBLE COUPLING design for low-power applications employs a single wire element to connect driving and driven shaft members. The wire, which is fastened to each coupling plate with machine screws, permits a 2-degree angular misalignment of shafts and some radial and axial shaft displacement. Designed by B. J. Popper of Kfar Ata, Israel, the coupling is capable of transmitting power without backlash in both directions.



When to COMMERCIALIZE

By T. Thomas von Pechy,
Patent Attorney
The Warner & Swasey Co., Cleveland

MANY inventions with potentially great promise are conceived only to be shelved within a short time as commercially impractical. Years or even decades later the same basic inventions suddenly reappear as highly successful "new ideas." This phenomenon can be and often is the result of premature commercialization before all of the components of an invention have reached a proper state of development.

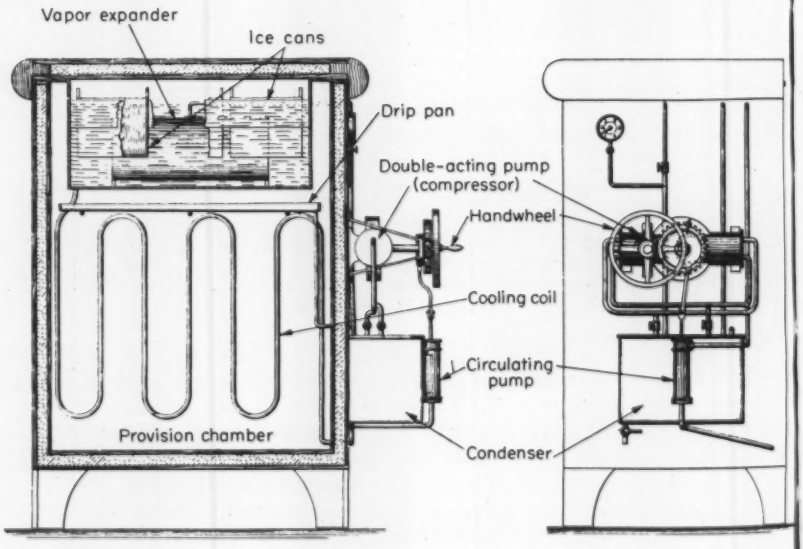
The basic question then is: When should an invention be commercialized? Experience indicates that before any invention can be successfully marketed, all of the necessary parts must have reached a stage of individual development wherein they are independently adaptable to commercialization.

However, no hard and fast rules can really be established to serve as a guide in specific cases. The factors involved can perhaps be best illustrated by tracing the development of certain in-

Early Refrigeration Developments

In 1879, Patent 213,487 (below right) was granted to J. G. Wolf on an "Apparatus for Refrigerating and Making Ice." This early unit contained all of the basic elements of the modern refrigerator. Cooling was accomplished by a pump, or compressor, driven by means of a handwheel. In his patent, the inventor states that the handwheel could be replaced by a pulley that was belt driven from a line-shaft. However, since homes were not equipped with line shafts, the inventor goes on to say: "In applying my apparatus to an ordinary refrigerator, it is essential that the pump shall be so constructed that it can be easily turned by hand, so that the temperature in the provision-chamber can be kept down by setting the pump in motion from time to time."

J. G. Wolf's invention was followed some years later by Patent 796,969 (at far right) issued in 1905 to W. C. Heister on a "Refrigerating Apparatus." In this patent, the inventor describes the application of a water motor to drive the pump of the refrigerator with the water being further employed to cool the condenser. As the inventor states, "Water under pressure is taken from any convenient source of supply and conveyed directly to the motor through a supply-pipe . . . and after passing through the motor . . . is discharged through a pipe which surrounds the condenser." The convenient source of water supply was probably the kitchen faucet.



INVENTIONS

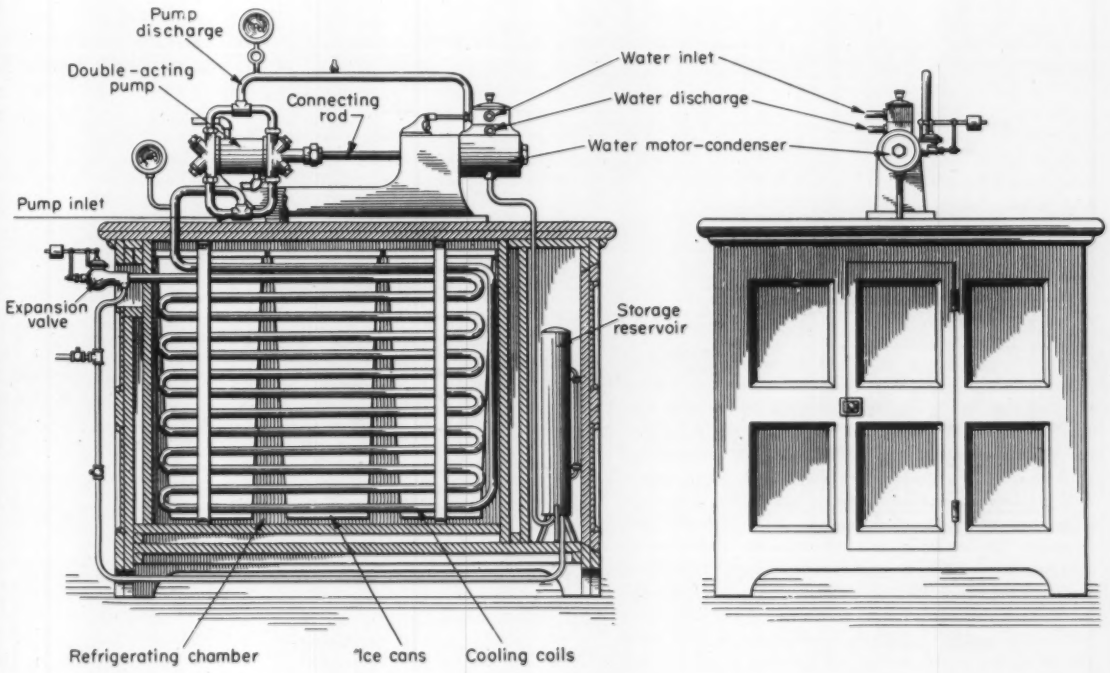
Factors to be considered in deciding the commercial future of promising inventions

ventions that are in common and widespread use.

Appliances: Today's household refrigerator had its beginning back in the middle of the last century. The early refrigerators were ice boxes and, as the name implies, employed natural ice to accomplish refrigeration.

As the use of natural ice for refrigeration increased, many patents were granted for machines for manufacturing ice. Among these early patents was one granted in 1897 to J. G. Wolf. This patent contained all the essentials of the modern refrigerator. It employed a pump (compressor) which was operated manually from time to time through a handwheel to provide the necessary refrigeration. The disadvantages of this type of drive are readily apparent.

While this arrangement may seem odd today, it must be remembered that electric motors and the distribution of electricity had not yet been



developed to a point where an electric-motor drive for the compressor was practical.

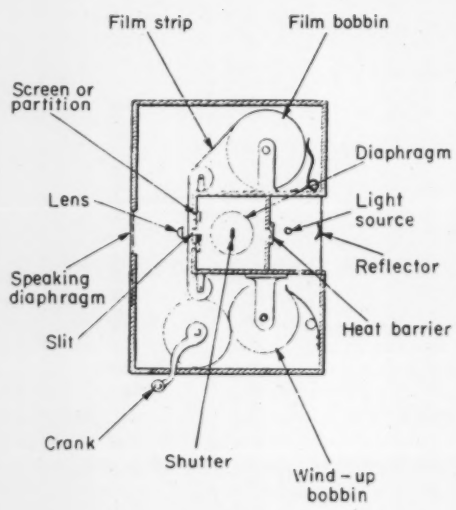
In 1905, W. C. Hiester received a patent on the application of a water motor to drive the pump of a refrigerator and the further use of the water to cool the condenser. A few years later the water motor was replaced by a small-sized fractional-horsepower electric motor which had been developed, and the problem seemed to be solved. However, refrigerators were still unsatisfactory, since there was considerable leakage in the compressor and all of the systems had to be manually controlled.

The compressor leakage problem was finally solved by the introduction of the hermetically sealed unit in 1911. A short time later, the control problem was resolved with the introduction of the thermostatic switch developed by E. J. Copeland for the first Kelvinator refrigerator in about 1918.

Thus, inventions in the field of household refrigerators had to be more or less shelved until developments in the fields of electric motors, compressors, and controls had advanced to a state which made the refrigerators economically feasible and completely foolproof.

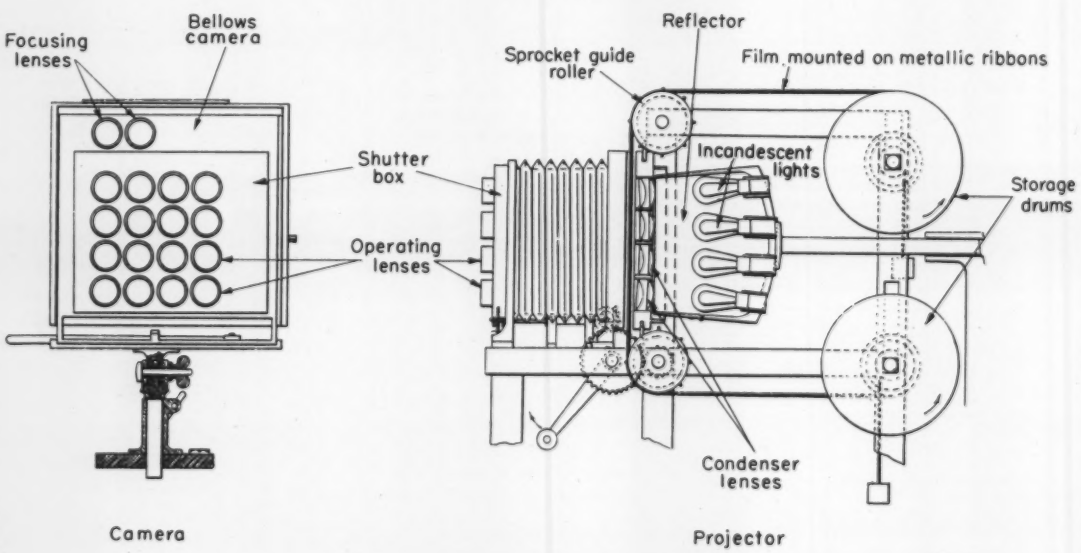
Motion Pictures: The history of sound movies follows a similar pattern. In 1889, C. H. Fritts filed

Basic Sound Motion Picture Invention



A device for phono-photographic reproduction of sound (top left) was the subject of a patent application filed by C. H. Fritts in 1880. Held under examination for thirty-six years, the application was finally issued in 1916 as Patent 1,203,190. The method of carrying out the invention is described in the patent as follows: ". . . I cause a sound which I wish to record to impinge upon a vibrating diaphragm and so vibrate a shutter in accordance with its own pulsations or sound waves. This shutter is arranged to vibrate across a beam of light and interrupt or manipulate it, producing variations in the light in accordance with the original sound waves or pulsations. This varying light I then throw upon a suitably prepared sensitive surface and record those variations upon it, as by photography."

While this patent was under examination, Patent 376,247 (below) was meanwhile granted to A. LePrince on a "Method of and Apparatus for Producing Animated Pictures of Natural Scenery and Life." The patent described a 16-lens movie camera and projector which used roll film. It is interesting to note that in his projector the inventor recognized the fact that the film had to be fed at a positive rate. He mounted the film between two metallic ribbons punched with sprocket holes which engaged the teeth of the drive sprockets.



a patent application on a system for photo-phonographic reproduction of sound. This application was under examination for a period of 36 years and was finally issued as a patent in 1916.

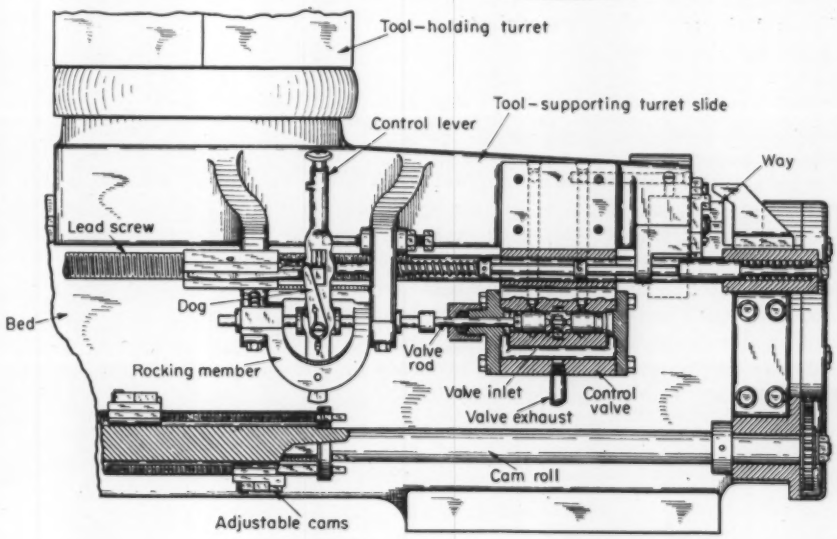
In the meantime, other inventors were also busy in the field. In 1888, a patent was issued to A. LePrince on a 16-lens movie camera and projector which used roll film. In his projector, LePrince recognized the fact that the film had to be fed at a positive rate and used a sprocket-type drive arrangement.

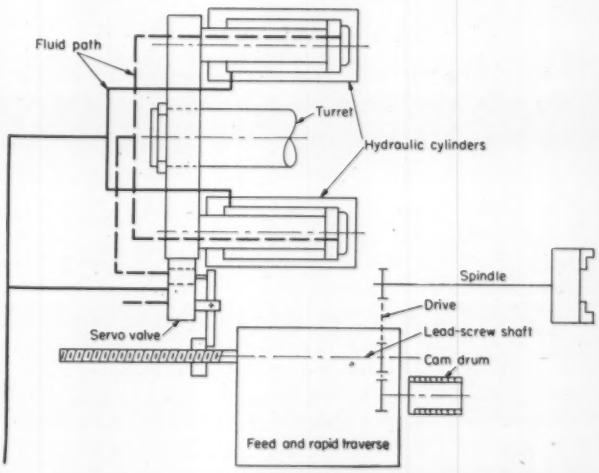
In the next year (1889), George Eastman invented his celluloid film which was a vital step in the progress of sound movies. Sound on film was thought of by Thomas Alva Edison in the same year. However, his developments in the field were along the line of combining his phonograph with the showing of movies.

The first successful sound-on-film demonstration was made by Eugene Lauste in 1906. However, it was not until 1928 that the public viewed its first all-talking movie entitled "Lights of New York." This was a Vitaphone production which had been developed by Western Electric. The sound-on-film movies had to wait for the field of radio to supply techniques for amplification and

Hydraulic Actuation of Machine-Tool Slides

Use of hydraulic power to move and position tool slides has been a subject of investigation and development since around the turn of the century. However, early systems were erratic in performance and could not be used for accurate work. One of the first promising developments in this field was detailed in Patent 1,936,446 (top left) issued to Edward P. Burrell on a "Control for Hydraulic Operating Systems." This invention provided a practical method for accurately controlling the movement of a hydraulically powered turret tool slide on a turret lathe. In operation, the slide is moved toward and away from the spindle of a turret lathe at either a feed or rapid traverse rate of movement by means of a hydraulic cylinder. A hydraulic control valve actuated by a manually operable control lever is fixed to and moves with the slide. A follower finger on the underside of the control lever engages an accurate lead screw which is driven in timed relation with the rotation of the work spindle of the turret lathe. Variations in rate of slide movement cause the follower to ride up and down on the flank of the lead screw thread, adjusting the action of the cylinder to maintain uniform slide movement.





Principles of this early invention are embodied in a recent tool slide design (bottom left) now being tested by The Warner & Swasey Co. This new development is intended to replace the massive mechanical apparatus presently used to move the turret slide of a lathe. The slide is powered by two hydraulic cylinders which are controlled through a hydraulic servo valve mounted to the slide. The servo valve is actuated by a lever that is spring-loaded toward a nonrotating nut on the lead screw. The lead screw is driven in timed relation with the lathe spindle.

wiring of theaters for sound, as well as for the refinements of the photoelectric cell which were received from Germany during the first World War. The first sound-on-film movie was made in the early 1930's.

Machine Tools: Another example of this pattern of development is given by the application of hydraulic power to move and position machine tool slides accurately. The early work in this field was done by James Hartness of Springfield, Vermont. His patent, which was issued in 1899, shows a hydraulic piston for moving the tool-carrying slide and provides for both rapid traverse and feeding movement.

It was recognized early that various factors such as viscosity and leakage of oil in the hydraulic system affected rate and accuracy of movement of the tool-carrying slide. These variables made it impossible to cut an accurate thread on the early hydraulically actuated machines. In 1930, Edward P. Burrell of The Warner & Swasey Co. filed a patent application for the correction of these difficulties. The patent issued in 1933, had as its object the provision of a control such that the turret slide on a turret lathe will be moved at a constant speed throughout its entire travel regardless of the amount or rate of leakage in any part of the hydraulic actuating system.

This invention made possible a degree of accuracy never before possible with a turret lathe equipped with a hydraulically powered tool slide. However, the invention was never put into production for the simple reason that at that time the hydraulic components necessary for effective operation of the system had not been sufficiently developed to make the invention commercially practical. Further development was necessary.

Applications of these basic ideas are widely evident in recent machine-tool designs. They have suddenly emerged as "new ideas" because basic components such as hydraulic pumps, servo valves, electric motors and electronic control circuits have only recently been developed to a state of reasonable dependability, although cost is still a problem in some cases.

Since the first experimental model of the Burrell patent was tested, The Warner & Swasey Co. has been conducting further research in the field using the latest components available. They have now built and are in the process of testing a hydraulically powered turret slide, embodying the principles of the Burrell invention.

The force necessary to move the turret tool carrier is supplied hydraulically and is accurately controlled by a simple lead-screw actuated servo-valve mechanism which is sensitive to very minute forces. The servo-valve mechanism, being of simple design and light in weight, will lend itself to almost any type of automatic control. If the exhaustive tests to which the mechanism is being subjected prove that the invention has come of age, it will then be put on the market and commercialized.

Practical Approach: This study of the development of different inventions in unrelated fields offers an insight of the pitfalls to be avoided in commercialization. Analysis of earlier successes and failures would seem to caution against immediate commercialization of any invention. Ideally, each component should be thoroughly tested with the latest techniques available. Then, perhaps, the basic criterion for final decision on the future of an invention is: Has each component reached the state of development necessary to make the invention perform in practice as was anticipated in its conception?

Tips and Techniques

Increasing Slide Rule Accuracy

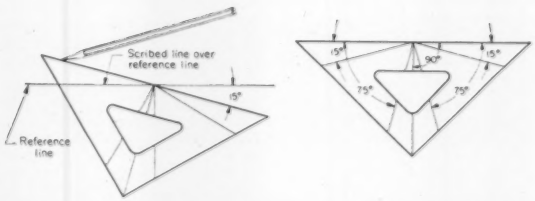
Although the slide rule is usually dismissed when four or five-place accuracy is required, it can provide this degree of accuracy if the proper technique is used. To illustrate this technique consider the multiplication, 98.765 × 56.789. This is broken down to

$$
\begin{aligned}
56 \times \quad 98 &= 5488 \\
56 \times 0.765 &= \quad 42.8 \\
0.789 \times \quad 98 &= \quad 77.3 \\
0.789 \times 0.765 &= \quad 0.6 \\
\hline
&\quad 5608.7
\end{aligned}
$$

Note that the initial multiplication is mentally corrected to 5488 from 5490 since the answer must obviously end with 8. This answer is as accurate as could be obtained using 5-place logarithms.—MORTON P. MATTHEW, *Ahrendt Instrument Co., College Park, Md.*

Drawing Odd Angles

Juggling of 30 and 45-degree triangles to draw 15 and 75-degree angles can be eliminated by using a triangle scribed as shown. Scribed lines should



be thin for accuracy. Darkening them with India ink will improve visibility.—GLENN L. DOWNEY, *University of Nebraska, Lincoln, Neb.*

A simplified graphical method for

Generating Gear Root Fillets

By Warren McNabb, *Gear Engineer*
National Broach & Machine Co., Detroit

CRITICAL factors in the production of accurate, quiet gearing are the shape and location of root fillets generated by hobs and rack-type cutters. The same details have a direct effect on load-carrying capacity. To an increasing extent, fillets are being generated by protuberance-type hobs which allow shaving cutters to blend tooth profiles with root fillets.

Scale layouts of the fillets help in the evaluation of gear tooth profiles and in the design of new hobs. A layout method intended particularly for teeth generated by protuberance-type hobs is described in this article. At scales of 50 to 150 times size, the layouts can be made on an average-size drafting board. Scales of the layouts are limited only by normal diametral pitch and gear base diameter.

Three tooth features are of major concern: the junction point between the undercut and the involute profile, the start of mating gear contact, and the depth of the gear root fillet.

Layout Method

The first step is to make a master profile chart on some transparent material. The chart has a master involute profile curve which is laid out by means of rectangular co-ordinates. The base circle diameter must be large enough to produce desirable scales for the sizes of gears being used. The scale of the layout is determined by the ratio of the base circle diameters of the master profile and the work gear. Depending upon the scale desired, a single master involute profile could be used for a number of rolling layouts.

In addition to the master involute curve, the master profile chart has opposing involute curves

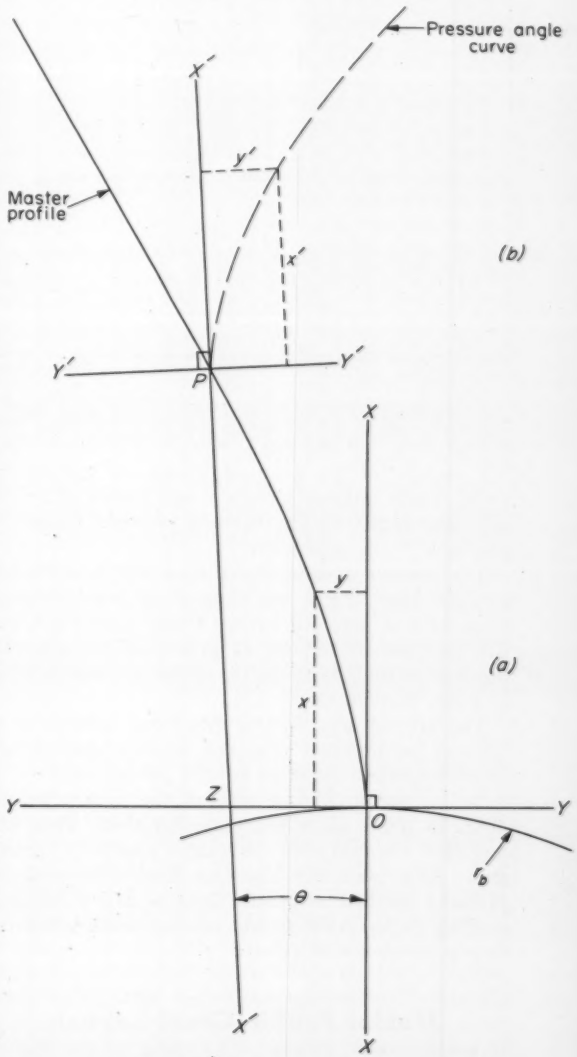


Fig. 1 — Construction of (*a*) master involute from point *O* and (*b*) pressure angle curve from point *P*.

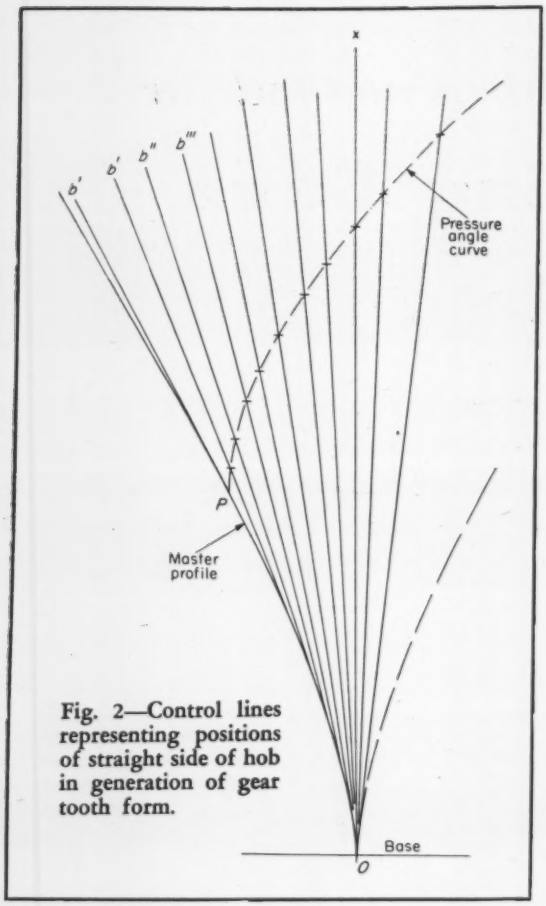


Fig. 2—Control lines representing positions of straight side of hob in generation of gear tooth form.

radiating from the original involute curve. These curves represent the loci of the pitch point between the profiles of the gear teeth and the generating tools. Their number, position, and points of origin are determined by the various pressure angles of the tools to be rolled out.

The master profile chart also has a series of straight lines which are tangent to both convolutions of the involute curve. These lines represent the position of the side or profile of the generating hob or rack tooth cutter at the various degrees of pitch diameter roll.

The second step in the graphical method is to lay out the profile of the hob or rack tooth cutter on transparent material to the proper scale.

To lay out a fillet, a copy of the master profile chart is made on a white background. Then the hob layout is laid over the master profile in various generating positions and the fillet generated by pricking the master profile chart print. A line connecting these prick points on the print gives the true generated root fillet.

Master Profile Chart Layout

In the development of the initial master involute profile, Fig. 1*a*, it is best to choose a base radius which will provide a fair enlargement of the tooth profiles in general use. The X and Y axes are laid off on transparent material. The intersection point O is the base of the involute curve laying on the circumference of the base radius r_b. The general equations for the involute curve are:

$$x = \cos \varepsilon + \varepsilon \sin \varepsilon; \; y = \sin \varepsilon - \varepsilon \cos \varepsilon$$

where ϵ is the roll angle for various points on the curve. By using a series of roll angles starting from 0 degrees, a table of values for x and y (basic co-ordinates) may be tabulated. Tables of these rectangular co-ordinates covering a wide range of roll angles have been published. Subsequent co-ordinates of points on the curve are determined by the product of the chosen base radius and the values of the co-ordinates for the various roll angles:

$$x' = r_b \; (\cos \varepsilon' + \varepsilon' \sin \varepsilon' - 1) \qquad (1)$$

$$y' = r_b \; (\sin \varepsilon' - \varepsilon' \cos \varepsilon') \qquad (2)$$

Sufficient points are calculated to form an accurate curve which represents the involute profile of a gear tooth from the base radius.

In Fig. 1*b*, the origin of the X and Y axes for the pressure angle curve lies at point P on the master profile. To establish point P, the new X axis is drawn through point Z on the original Y axis at an angle θ from the original axis. The

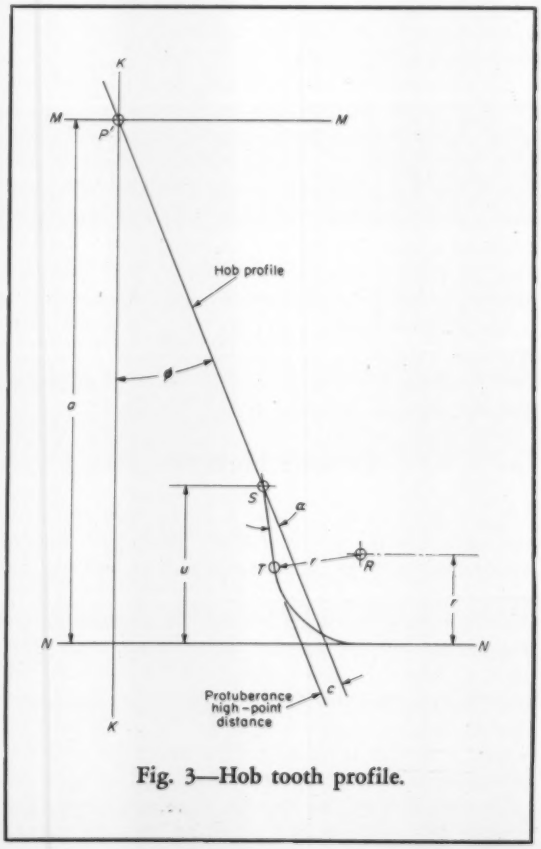


Fig. 3—Hob tooth profile.

intersection of this new X axis and the master profile curve is point P. Therefore,

$$\text{arc } \theta = \text{inv } \phi = \tan \phi - \text{arc } \phi$$

$$OZ = r_b \tan \theta$$

where ϕ is the pressure angle of the hob used in generating the gear tooth form. The new Y axis is drawn perpendicular to the new X axis through point P.

The radius r to the point P becomes the base radius of the pressure angle curve which is of involute form and opposed to the curve of the master profile. Radius r is determined through use of the master profile base radius and the chosen pressure angle:

$$r = \frac{r_b}{\cos \phi}$$

Substituting r for r_b in Equations 1 and 2 and using the same roll angles and basic co-ordinates as used for the master involute, the co-ordinates for the points on the pressure angle curve are easily calculated and plotted. Subsequent curves are established and plotted through the use of various pressure angles.

The straight lines shown in Fig. 2 are the control lines representing the straight side or profile of the hob tooth generating the gear tooth form. They are drawn tangent to the master involute profile and intersect all pressure angle curves. Their number depends only upon the desired accuracy of the gear fillet layout and their position relative to the original X axis is of no consequence. Since the flank of a hob tooth is always tangent to the profile of the generated gear tooth, it is important that these straight lines are always tangent to the master involute profile.

The steps illustrated in Figs. 1 to 3 complete the involute profile chart. Actual generating layout work is done on prints of the chart, not on the original drawing. In this manner, gears of different diametral pitches and pressure angles may be generated on the same form. The scale of each layout is determined by the ratio of the base radius of the master involute form and the base radius of the gear to be generated:

$$s = \frac{r_{bl}}{r_{bg}}$$

where s is the layout scale, r_{bl} is the base radius of the master layout, and r_{bg} is the base radius of the gear. The scale is used to determine the dimensions of the hob profile which generates the gear tooth fillet and undercut. The height of the fillet and undercut is then reconverted to a radial distance above the gear base circle.

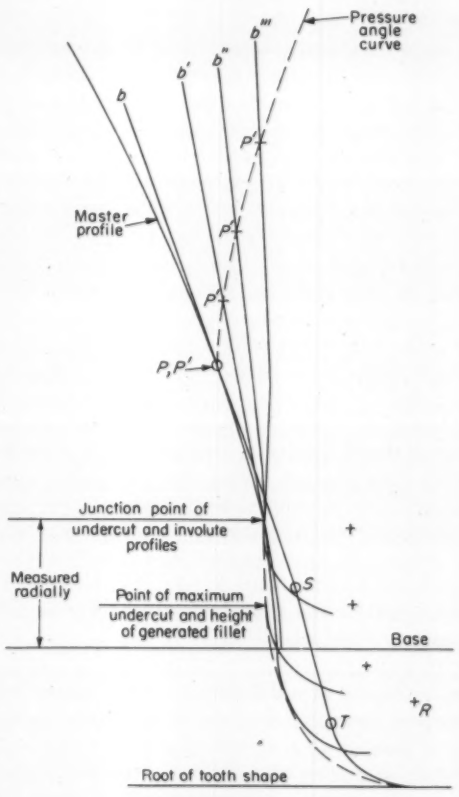


Fig. 4—Generation of root fillet by hob protuberance.

Hob Tooth Layout

The hob tooth form is laid out as shown in Fig. 3. This layout is made on transparent paper using the scale calculated from Equation 3. Construction lines *KK*, *MM* and *NN* are laid off first. The distance a is the radial dedendum of the gear tooth space from the pitch radius r to the desired or produced root radius r_r:

$$a = r - r_r$$

Point P' is the pitch point on the hob profile which coincides with point P on the master profile. A line representing the main profile of the hob is laid off through P' at pressure angle ϕ to line *KK* and extending to the tip of the tooth on line *NN*. The amount of protuberance high point is measured off parallel to the hob profile, and the desired tip radius of the hob is laid in tangent to the distance c and the construction line *NN*. The approach to the protuberance is made tangent to the tip radius at point T and intersecting the hob profile at point S. The distance u to the start of approach is usually given on hob tool prints supplied by the vendors. However, 5 degrees is a good approximation of the angle α for the approach. Points P', S, T and R are encircled for future use. In order to regulate or control the amount and position of undercut produced, it may be necessary to change the tip radius, protuberance and points of inter-

section several times before completing a satisfactory tooth form.

When no protuberance formed undercut is desired, it is only necessary to make the tip radius tangent to the tip and profile of the hob. Then point T will lie on the hob profile and point S will cease to exist.

Using the Master Profile

For most efficient use, prints or duplications of the master profile chart should be of the type which show the lines of the layout on a white background. Then as shown in Fig. 4, the layout of the hob is laid over the master profile with point P' on the hob profile directly over P on the master profile and with the main profile of the hob coincident with the initial control line b which is tangent to the profile at point P. Using the point of a pricker, point P' is aligned with P as perfectly as possible and then points S, T and R on the hob form are punched through to the print below. A compass set to the scaled tip radius of the hob is centered at the transferred point R and the radius is inscribed through the transferred point T. Points S and T are joined by a straight line. In all cases point S shou'd fall on a control line coinciding with the main profile of the hob. Subsequent positions of the hob tip are determined by the same procedure, using the intersection points between the control lines and the pressure angle curve for locating point P'. As P' proceeds along the pressure angle curve, the fillet and the undercut are formed to the root of the gear tooth space by the hob tip radius, protuberance and approach.

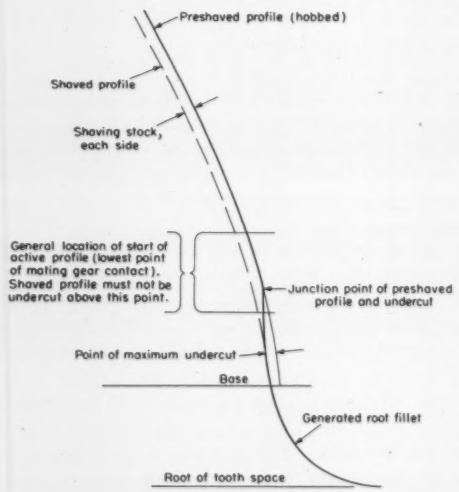

Preshaved profile (hobbed)
Shaved profile
Shaving stock, each side
General location of start of active profile (lowest point of mating gear contact). Shaved profile must not be undercut above this point.
Junction point of preshaved profile and undercut
Point of maximum undercut
Base
Generated root fillet
Root of tooth space

Fig. 5—Relation of hobbed profile, root fillet and shaved profile.

Applications

This graphical layout method is particularly useful when the cutting tool design is given and the resultant tooth form is desired. It can also be used in the design of a new hob or rack-type cutting tool for a specific gear tooth profile. The fillets resulting from the use of short or long lead hobs can be readily obtained by this method. It is only necessary to calculate the gear characteristics at the desired pressure angle of roll with the hob. Then a hob form with the same pressure angle of the gear tooth form can be rolled out in the manner described.

Controlled undercutting of the gear profiles is put to most practical use when considering the profile form prior to a shaving operation. A well engineered undercut moves the root fillet away from contact with the tip of the shaving cutter tooth and provides for a smooth blending of the shaved profile and the generated fillet. Proper design of gear and hob teeth can produce an undercut which is equal to or a little greater than the amount of shaving stock to be removed from the flank of the gear tooth, Fig. 5. The generated fillet must be regulated so its maximum height does not encroach upon the shaved profile. Junction of the preshaved profile and the undercut should be closely controlled to allow as much involute overlap as possible at the start of action with the shaving cutter.

A most important contributing factor in the development of a profile undercut is the lowest point of mating gear contact (the start of active profile). In order to provide mating gears with the best possible rolling conditions, the shaved portion of the gear tooth flanks must overlap the full active profile. Therefore, it is most imperative that the preshaving hob be designed to leave some shaving stock at this point. Quite often the design of the gear train does not permit a hob design which will produce an undercut whose junction point comes below the start of active profile. In such cases, it is permissible to allow the junction point to come slightly above the critical point providing the shape of the undercut is such as to allow at least 0.0005-in. of stock at the point of mating gear contact. When crown shaving is contemplated, it is advisable to increase the depth of undercut by the amount of crown desired on one flank. In this manner the possibility of a step or notch in the fillet left by the shaving cutter at each end of the gear face will be minimized or completely eliminated.

Although this method of generating a gear tooth form by layout is most practical when dealing with undercuts, it is adaptable for other forms produced by the generating tool. For example, by constructing and extending the master involute profile for either side of the tooth space, the entire flank of the tooth from base radius to tip can be exposed. With the pressure angle control lines expanded and the hob form constructed in full, the entire gear tooth form can be generated.

DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY (Seventh of a Series)

The importance of proper control design to ease of maintenance of electronic equipment cannot be overemphasized. Of course, a recognition of when certain maintenance controls are needed or not is of primary concern. Then location, position markings, scales, and labels must be selected. This article outlines basic procedures in this area of electronic equipment design.

Design of Maintenance Controls

By John D. Folley Jr. and James W. Altman
Research Scientists
American Institute for Research
Pittsburgh

CONTROLS are the means by which a technician or operator transfers information into electronic equipment. Many of the controls designed for the operators of the equipment are also used by the technicians. Some controls are built into electronic equipment strictly for maintenance purposes. Maintenance controls include not only knobs and switches but also tool-operated controls, such as screwdriver adjustments.

Since the design of controls is not unique to maintainability, considerable design information on this subject is available from other sources.* Consequently, only considerations judged particularly pertinent to maintenance are presented here.

The designer must first decide when a maintenance control is needed. It must be realized that special controls for maintenance must be designed into the equipment whenever the operator's controls cannot put information specified by maintenance procedures into the system.

The need for maintenance controls should be determined when procedures are first developed during design of the developmental model of the system. It will then be possible to make equitable compromises among circuit-design requirements, effective control design and location, and maintenance procedures design if initial procedures require building of controls in unfeasible locations.

Control Types and Shapes: Use hand-operated knobs where controls are frequently used instead of ones requiring a tool to operate. For example,

Fig. 1—Three recommended types and shapes of hand-operated control knobs. A bar-shaped pointer, top, is suggested for selector switches. For continuous rotation for a few turns, use a round knob, middle. For many turns use a round knob with a crank, bottom.

*J. H. Ely, R. M. Thomson and J. Orlansky — "Workplace Layout and Control Design," *WADC Technical Report.*

where on-off switches are required, use toggle types. If selector switches are called for, use a bar-shaped pointer as shown at the top of Fig. 1.

Where the design requires continuous rotation for a few turns, use a round knob with no pointer, Fig. 1. An orienting dot may be useful for some purposes, for example, in a volume control. However, if continuous rotation for many turns is needed, use a round knob with a crank, Fig. 1. The crank should be hinged and fold into a recess in the knob when not in use.

Direction of Control Movement: Functions regulated by controls should increase when the control is moved clockwise, forward, or upward. Conversely, they should decrease when the control is moved counterclockwise, backward, or downward. Toggle switches should be "on" in the up or right-hand position and "off" in the down or lef-hand position.

Control Size: The size of control knobs should increase as the force required to operate the control increases.

Make knobs for precision settings about 2 in. in diameter. Knobs for noncritical settings need only be about 1 in. in diameter.

Tool-operated controls should be operable by a screwdriver or other tool of medium size. Technicians are more likely to have a medium-sized tool than a large or a small one.

When vernier controls are mounted on concentric shafts, the larger diameter knob should control the fine adjustment. This gives maximum precision.

Location of Controls: For units having operator's controls, the controls for maintenance should be located on the front panel behind an access door. The operator's front panel should be accessible in the installation, insuring that the controls will also be accessible to the technician.

For units without operator's controls, all maintenance controls should be located on one side of the unit. Use a side that will be accessible in the normal installation.

It can be said that in the design of all units, all controls should be located on the *outside* of the units. Ideally, all adjustments would appear on a single adjustment panel. Also, locate all controls where they can be *seen* and *operated* without disassembling or removing any part of the installation. For example, do not put any controls under the pilot's seat or against the side of a van in a portable ground installation. Locate controls where cabling will not cover them. Keep controls away from high-voltage points and hot tubes. Use extension shafts if necessary.

Place controls on the panel in the order in which they are to be used normally, Fig. 2. This is particularly important for controls used in fixed procedures. This recommendation should *not* be followed if it will cause conflict with the operator's procedures.

If screwdriver-operated controls must be mounted inside units, bring controls as near to the outside of the unit as practicable. Use extension shafts if necessary. Provide accesses and guide shafts surrounding the screws.

Control Scale Markings: Position markings should be descriptive rather than coded. The markings should describe a condition, an action, or an indication as illustrated in Fig. 3.

Scales on controls should be only fine enough to permit the required accuracy in setting. In gen-

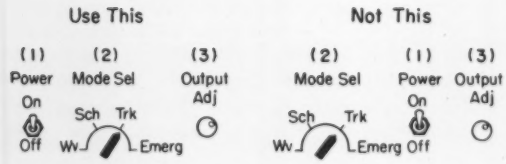


Fig. 2—Locate controls in order normally used.

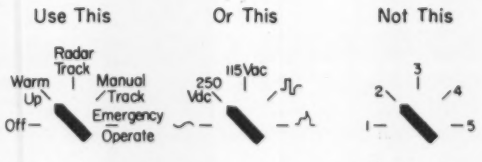


Fig. 3 — Make position markings descriptive rather than coded.

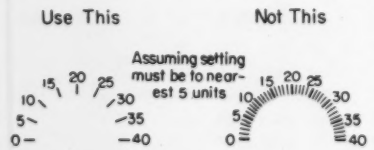


Fig. 4 — Don't make scales too fine.

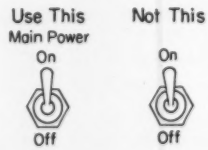


Fig. 5 — Name and label all controls.

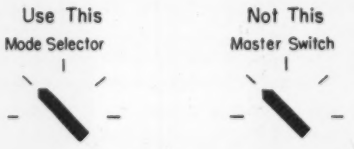


Fig. 6 — Function of control should be stated on label.

eral, interpolation should not be required, nor should extra scale markings be included, Fig. 4.

Labeling and Coding: Every control should have a name and should be labeled with that name, Fig. 5. Labels should state the function of the control, not the type of control mechanism, Fig. 6.

Controls should be numbered in sequence of their operation whenever they are used in a fixed procedure, Fig. 2*a*. This sequence number should be used in addition to the name label.

Control Force: Controls should have smooth, even resistance to movement except for detents on selector switches. Multiposition selector switches should have sufficient spring loading so that a switch cannot inadvertently stop or be left between detents.

Pushbuttons should not be so heavily spring-loaded that they cause uncomfortable pressure against the finger.

BIBLIOGRAPHY

This article is the seventh in a co-ordinated series by John D. Folley Jr. and James W. Altman. Previous articles, and issues of MACHINE DESIGN in which they appeared are:

Designing Electronic Equipment for Maintainability	June 14, 1956
Units, Assemblies and Subassemblies	June 28, 1956
Covers and Cases	July 12, 1956
Wiring, Cables and Connectors	July 26, 1956
Maintenance Accesses	Aug. 9, 1956
Test Points	Sept. 6, 1956

Tips and Techniques

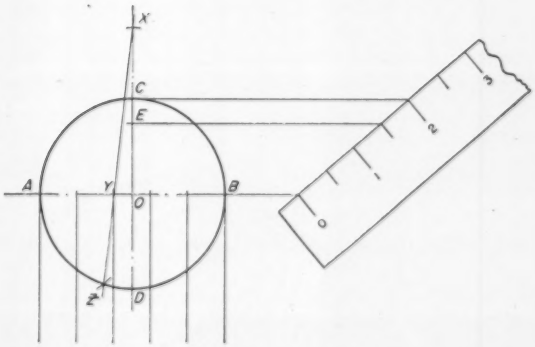
Sample Boards

Easily accessible samples of standard parts such as springs, bellcranks, links, nuts, bolts, screws, washers or other parts can save a designer's time as well as a firm's money by eliminating time spent

searching for a standard part or designing time when a standard part to do a job is already available. One way to achieve this result is to mount one of all such standard parts on boards and keep them in the engineering department. Such boards for springs, links and bellcranks are shown. In the case of the spring board, springs are firmly anchored at one end so that the designer can go to the board and stretch the spring as an aid in evaluating its suitability for a particular application.—JOHN L. MOODY, *Friden Calculating Machine Co. Inc., San Leandro, Calif.*

Dividing a Circle into Parts

To divide the circumference of a circle into any number of equal parts, *n*, first divide diameter *AB* into the number of equal parts into which it is wished to divide the circumference. Then divide radius *OC* into four equal parts. With a compass set for distance *OE*, place the point at *C* and mark off *CX*. A line drawn from *X* through *Y* and extended to the circumference of the circle, establishes *Z*. The arc *AZ* is then equal to the circumference divided by the number of parts. — ZEN WHITENIGHT, *Union Switch and Signal Div., Westinghouse Air Brake Co., Swissvale, Pa.*



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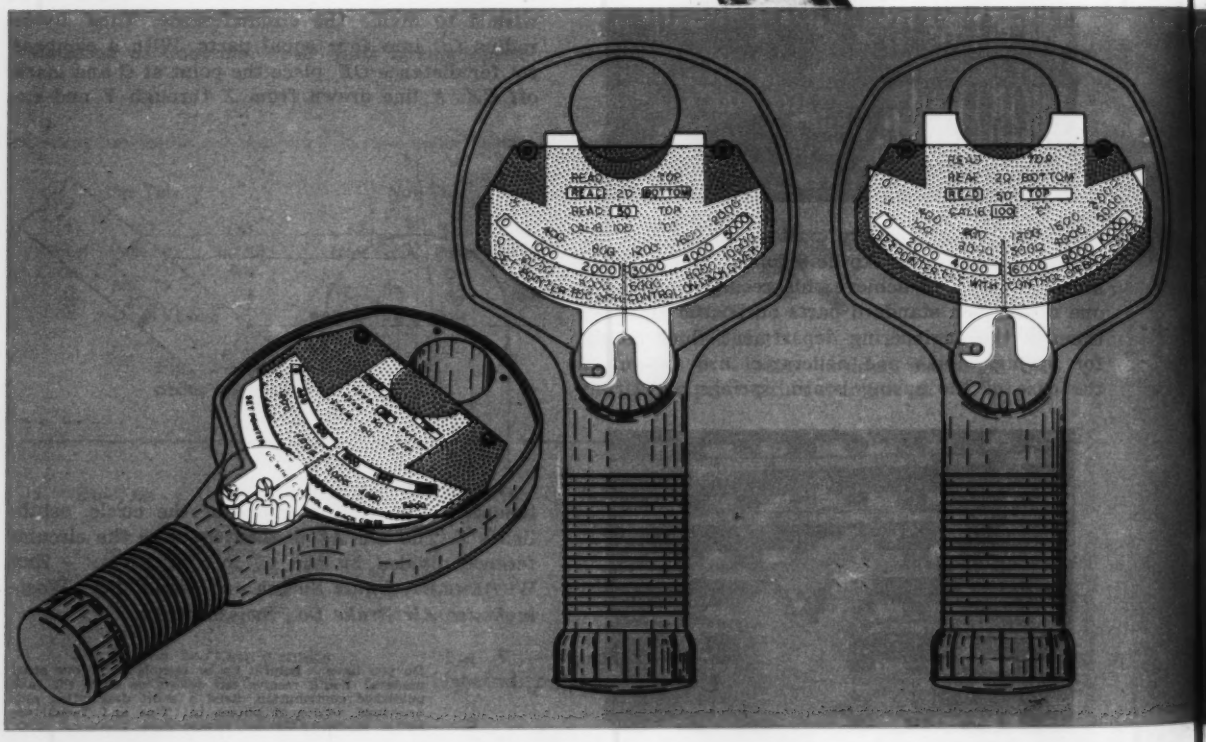
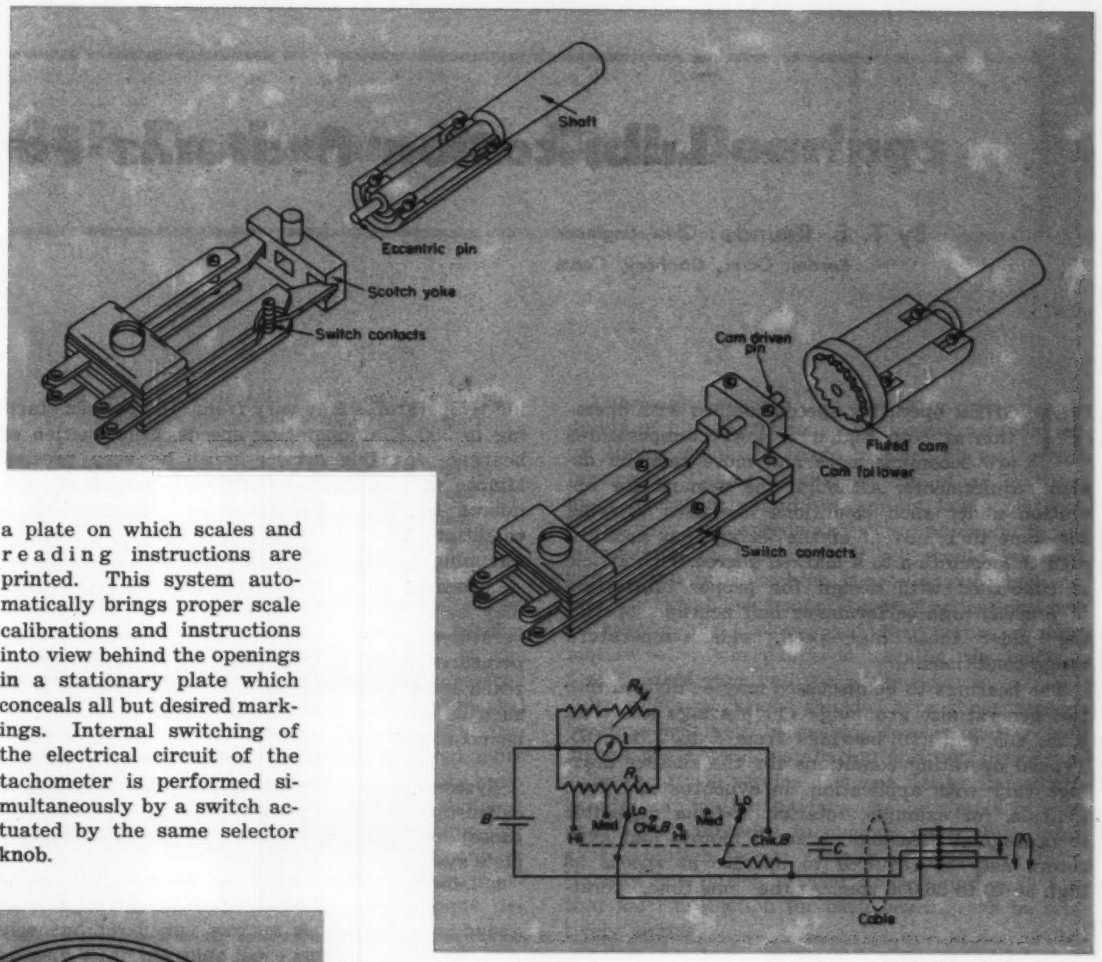
Tachometer Redesigned for Easy Reading

INCREASED handling ease, lighter weight and easier reading are results of redesign of a hand tachometer. A product of Metron Instrument Co., the tachometer is a completely self-contained, hand-held instrument with the exception of the probe which is connected to the hand unit by a small electrical cable.

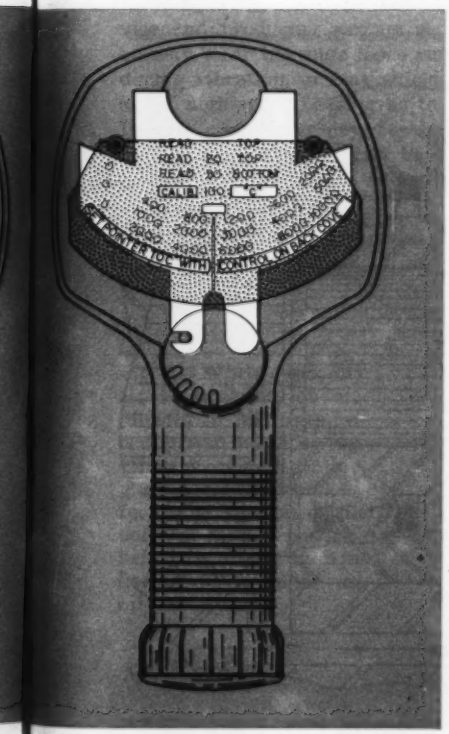
Three models are made to measure speeds from 200 to 10,000, 100 to 5000, and 20 to 1000 rpm. These speed ranges are covered in three steps selected by a knob on the front of the tachometer. Accessory adapters can be used to extend the range of any one of the models. Adapters are also available to convert tachometer readings directly to linear velocities in feet per minute. Complete with adapters in its carrying case, the unit measures 11 7/16 by 7 5/16 by 3¾ in. and weighs 4¾ lb.

Scale changing is accomplished by rotation of the selector knob. A crankpin rotating with the knob moves





a plate on which scales and reading instructions are printed. This system automatically brings proper scale calibrations and instructions into view behind the openings in a stationary plate which conceals all but desired markings. Internal switching of the electrical circuit of the tachometer is performed simultaneously by a switch actuated by the same selector knob.



Speed sensing element is a double-pole, double-throw switch. One type of element uses a scotch yoke to provide one complete switching cycle per revolution of the shaft for high-speed applications. A fluted-cam element is used for lower speeds and provides ten switching cycles per revolution. Use of self-lubricating materials and antifriction bearings in these switching heads is said to result in life in excess of 2 billion switching cycles.

The tachometer indicator is an electric meter with an associated pulse counting circuit. Pulses are generated by the tachometer head, a small battery and a condenser. Battery and condenser are in the tachometer's indicating unit. Range changes are accomplished simply by switching to introduce more or less resistance into the circuit. A calibration checking circuit and adjustment are provided to allow compensation for battery condition as well as slight changes in the values of the circuit components. Accuracy of this basic circuit is 1 per cent of full scale.

Contemporary Design

Lubrication Systems For

By T. E. Rounds, *Chief Engineer*
Barden Corp., Danbury, Conn.

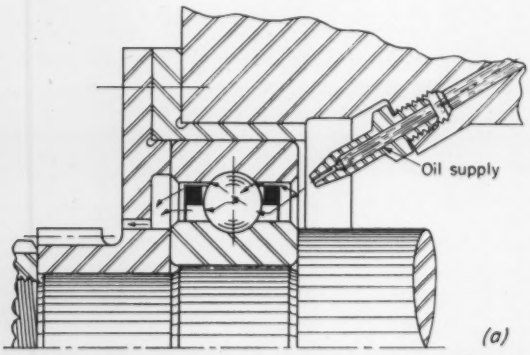
HIGHER operating speeds coupled with operation at both higher or lower temperatures are becoming more and more common design requirements. Although the demand for operation under such conditions has been growing for some time, advent of the jet age has accentuated this condition to a marked degree. This article is concerned with design for proper lubrication of precise, high-performance ball bearings operating under these high-speed, wide temperature range conditions.

The bearings to be discussed may be divided into two general size groupings (1) bearings less than 1 in. OD and (2) bearings from 1 to 3 in. OD. Typical operating conditions for the smaller bearings vary with application. In synchros and gyro gimbals, for example, rotation is from negligible to occasional. Bearings in small motors and gyro rotors may be required to operate at speeds as high as 20 to 30,000 rpm. At the same time, operating temperatures may vary from −65 F when starting to 300 F at operating speeds. Construction of bearings for this service must be very precise. Minute dirt particles, even those smaller than 1 micron in size, are serious hazards under such conditions as is any increase in friction caused by gumming or sludging of the lubricant.

Operating requirements for the larger bearings may be even more stringent. Again starting temperatures may be as low as −65 F. Running temperatures at speeds of 20,000 rpm and higher often reach 400 F. Operation at even higher temperatures such as 600 to 800 F may be required in the very near future.

System Requirements: A lubrication system is called upon to perform certain tasks in addition to those ordinarily thought of as lubrication. Complete system requirements are:

1. Lubrication of sliding areas such as contact



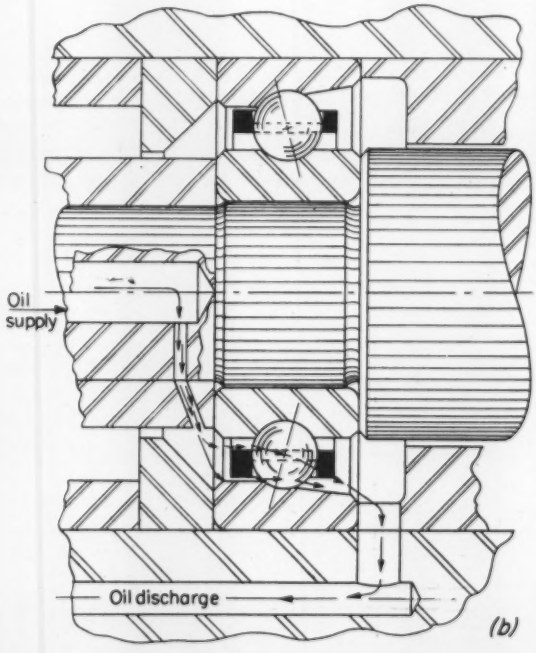


Fig. 1—An oil jet system provides the positive supply of clean, cool oil necessary to successful operation of a heavily loaded ball bearing at high speed and high temperature. Two methods of feeding the oil to the bearing are shown here. A stationary jet, *a*, directs oil from a passage in the housing to the rotating parts of the bearing. Another commonly used method, *b*, is to direct oil to the bearing through drilled holes in a rotating shaft and housing.

High-Performance Ball Bearings

area between balls and rings, and lubrication of border line areas where true rolling motion is violated to a greater or lesser degree.

2. Cooling to avoid softening of ring material and to simplify the lubrication problem generally.
3. Protection of bearing parts from corrosion.
4. Assisting the seals in preventing harmful foreign matter from entering the bearing.

Lubrication system design to be properly effective in promoting long life of antifriction bearing applications must provide for protection of the bearing against ingress of foreign matter as well as escape of lubricant. This is quite fundamental and has been preached for years but is still frequently neglected. Such provisions are even more important in connection with high-precision bearings since choice of such bearings has been dictated by need for superior performance requiring low torque, low vibration, accuracy of rotation, and/or endurance at extremely high speeds. Foreign matter may clog bearings, stalling a low-torque device and producing serious errors and roughness, or may wear bearings loose running at speed, producing vibration, or may so clog or otherwise damage a high-speed bearing as to cause rapid failure. In this connection dry powdered lubricants have always seemed to be and have frequently proved to be unsuitable for use in rolling-contact bearings.

Lubricant Selection: At an early point in the design of high-performance equipment a fundamental choice should be made between oil and grease lubricants. Choice of one or the other is based upon operating conditions and is fairly clearcut.

For very slow speeds and where minimum torque is essential, a low-viscosity oil should be used. Grease will produce high torque peaks which are accentuated at low temperatures. Applications such as gyro gimbals, slow-speed gear trains, synchro motors, etc., where speeds usually run below a few hundred rpm, call for oil lubrication.

In such applications shielded type superprecision bearings will help to exclude foreign matter both during the critical installation and test period and subsequently in service. Housing design immediately adjacent to the bearings can be simple in form and mainly intended to exclude dust, since lubricant retention is not usually a serious problem. Usually the device is well housed and sealed so that local protection for each bearing can be relatively simple.

As speeds increase beyond a few hundred rpm, grease is preferred. This is because bearings require more positive lubrication and have the tendency to purge themselves of a free fluid. Retention of grease in a simple housing enclosure is less of a problem than with oil. Furthermore, as speeds in-

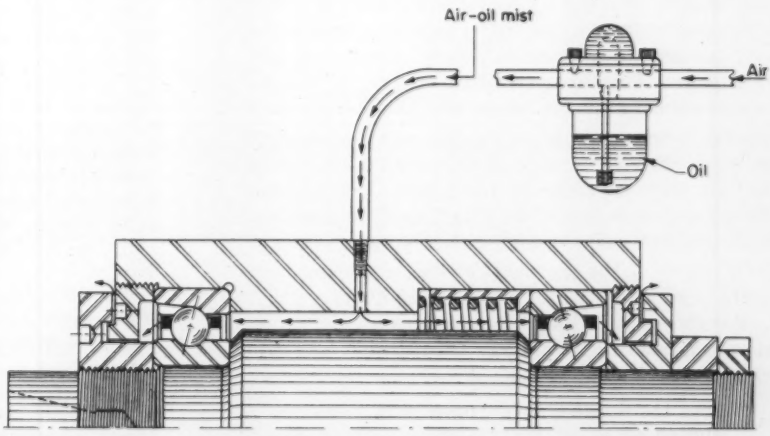


Fig. 2—When clean, dry air is available, an air-oil mist or oil fog lubricating system can be very efficient. Good cooling, good lubrication and effective prevention of the entry of foreign particles help to offset the inherent oil waste of the oil mist system.

XUM

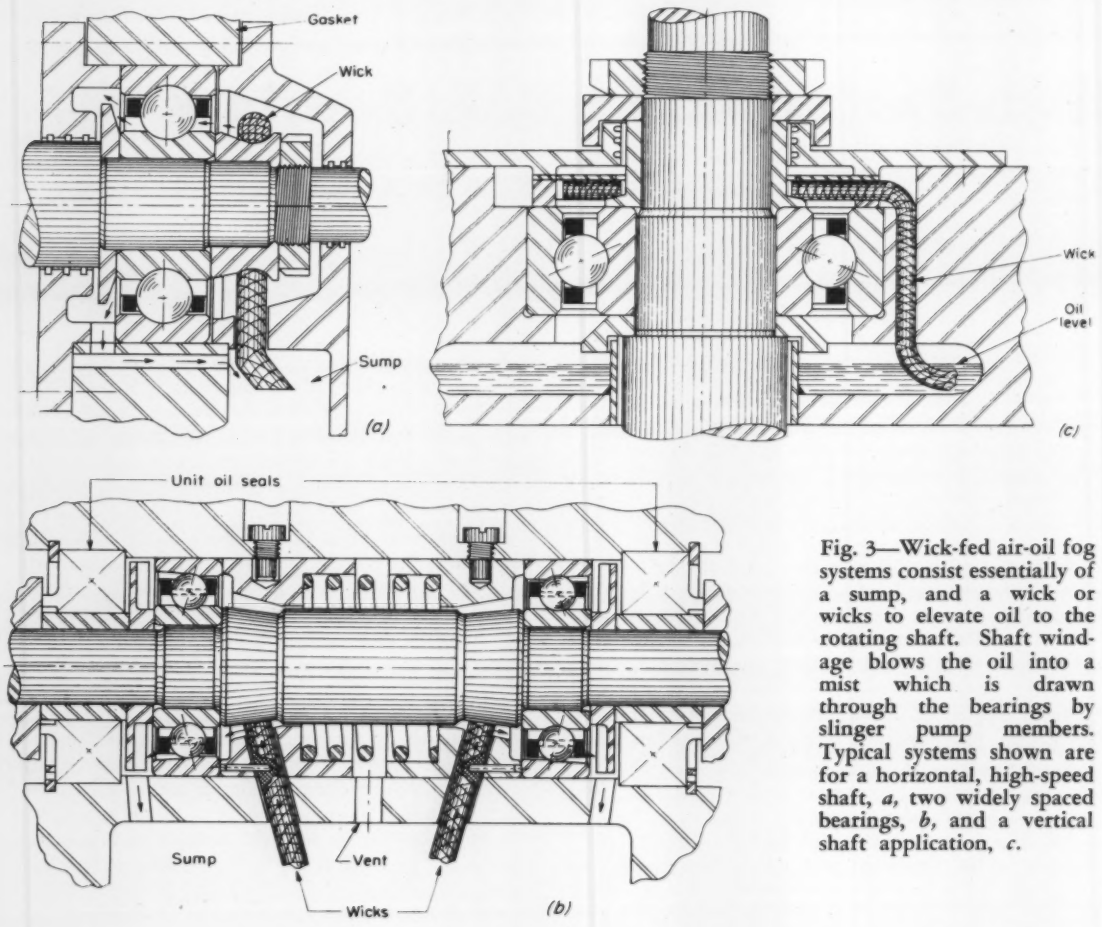


Fig. 3—Wick-fed air-oil fog systems consist essentially of a sump, and a wick or wicks to elevate oil to the rotating shaft. Shaft windage blows the oil into a mist which is drawn through the bearings by slinger pump members. Typical systems shown are for a horizontal, high-speed shaft, *a*, two widely spaced bearings, *b*, and a vertical shaft application, *c*.

crease, torque peaks of grease are less accentuated due to *running-in* of lubricant. The torque peaks of grease lubricants at very low speeds or breakaway conditions become of less importance as more and more running at speed is involved.

A point is finally reached in regard to both speed and temperature, however, where greases usually fail to give long life performance. This is because relatively inert grease *packs* are not good cooling agents, whereas fluid lubricants can be supplied in a manner to provide better cooling action to hot running bearings. When speeds reach about 600,000 *DN* (product of bearing bore *D*, millimeters, and speed *N*, rpm), and as temperatures reach 300F many of the presently available greases have a life of no more than a few hundred hours.

For the very high-speed conditions special attention is needed to the following conditions and provisions where *oil* must be used.

1. Feed the bearings at all times with clean, unsludged oil or oil mist. If the oil system also lubricates gears, sleeve bearings or other moving parts, arrange if at all possible to pass the cleanest oil to the ball bearings first as these members are most easily damaged. Use oil filters.
2. Feed the bearings positively with pressure spray or pressurized or induced draft of air and oil. Spray systems are ideal because they provide cooling and overcome the resistive bearing turbulence. If pressure spray or oil mist cannot be used because of weight and space limitations, use wick feed and create suction through the bearings by slingers or pumping devices to overcome rotating bearing resistance.
3. Anticipate adverse air pressure differentials to avoid starving one or more bearings of lubricant. Positive, specially designed rubbing seals may be needed if differential air pressures outside the bearing housing cannot be reduced to the barest minimum.
4. Provide labyrinth seals to keep out dirt and dust.
5. Design housings so that minimum free air space is left in the housing. This is particularly necessary on grinding spindles where cooling of housing, and shrinkage of internal air volume

may suck in liquid coolants contaminated with abrasives during idle periods.

Further elucidation of the subject of lubricating system design is divided into two general systems —oil systems and grease systems.

Oil Lubricating Systems: As previously mentioned, very slow-speed applications (intermittent running below a *DN* of 10,000) can be handled with shielded bearings supplemented by a simple cap or housing end-bell enclosure. A few drops of low-viscosity instrument oil will suffice for a few thousand hours of service. Synthetic oils with low evaporation characteristics are ideal for this purpose. Sensitive devices such as gyro gimbals, synchro receivers and slow-speed accurate gear trains have little need for more than a drop or two of oil in each bearing. Excess quantities cannot be tolerated particularly if optical parts are involved.

OIL JET SYSTEMS: Where a positive pressure supply of oil is available as in certain of the more complex aircraft accessory applications, the slower-speed bearings (speeds below 200,000 *DN*) can usually be properly lubricated by oil drip or splash, but the higher-speed bearings are best lubricated with oil spray. This is particularly necessary above 300F bearing temperature, where cooling the bearing becomes more critical. While bearings can be supplied with rings and balls of materials properly heat treated for temperatures above this figure, the combination of high loading, high speed and high temperature adds other critical adverse factors which can be mitigated to a great degree by a positive supply of clean, cool oil, Fig. 1.

In some cases, particularly, where speeds exceed 1,000,000 *DN* and loads and temperatures are high, multiple sprays on each side of the bearing have been found necessary to insure cooling and wetting of all critical surfaces. Oil jets should be directed so as to cool the inner ring of the bearing in order to avoid excessive expansion of this member and radial preloading of the bearing.

One complication of the high-temperature situation which has become increasingly evident in aircraft in recent years is the gradual disappearance of heat sinks. For many years cooling of the oil sump to moderate temperatures well below 300F has been possible. However, with the advent of higher and higher flying speeds and greater heat transfer to the aircraft structure and equipment, cooling bearings by spray systems has tended to become less satisfactory. Soak back of heat from associated power plants has further complicated the situation. Where heavy loads are involved at high speeds, the oil jet system should be used.

AIR-OIL MIST PRESSURE-FED SYSTEMS: If a source of clean, dry air is available and some wastage of oil is not objectionable, a pressure-fed mixture of oil in air has very definite advantages. Typical systems applied to machine-tool spindles, Fig. 2, have the following advantages:

1. The air-oil mixture is continuously fed, cool-

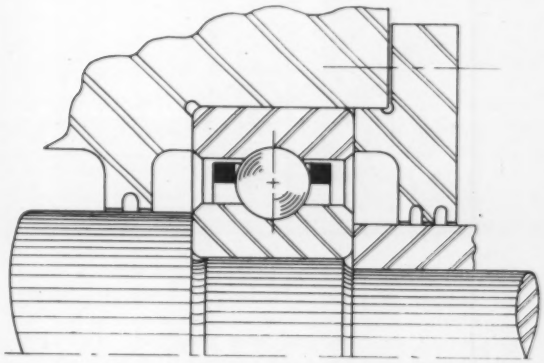


Fig. 4—Simplest type of enclosure for a grease-lubricated bearing uses a simple cap. This type of housing is not suitable where dust or other contaminants are likely to be encountered.

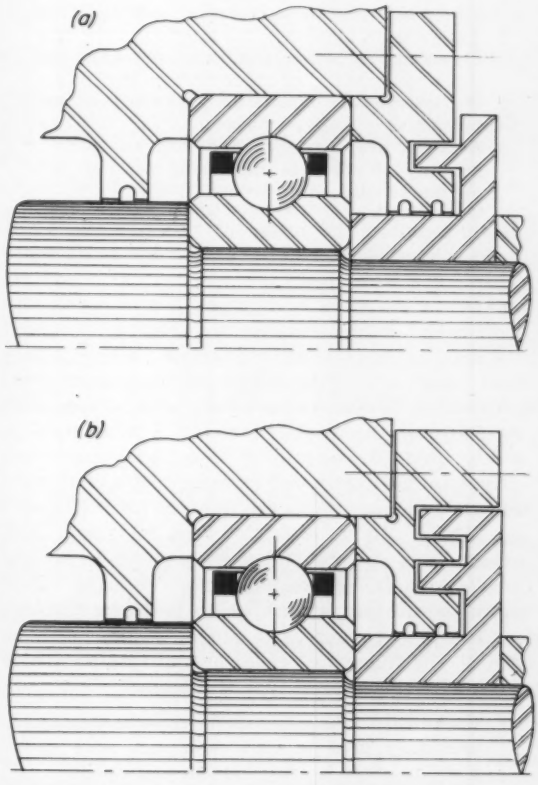


Fig. 5—Single, *a*, or double-labyrinth enclosures, *b*, are necessary when dust or other materials are likely to enter the housing of a grease-lubricated bearing. The single labyrinth will serve under moderate conditions while the double labyrinth is required for severe conditions.

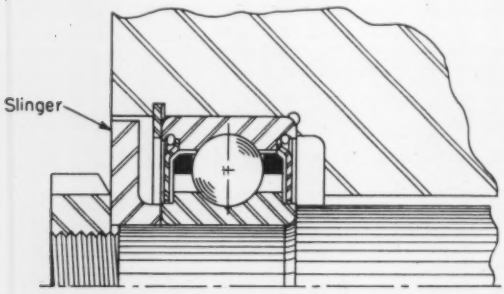


Fig. 6—When shielded bearings are used, a simple slinger may be sufficient to keep the bearing clean. The slinger serves as a rotating baffle to prevent air flow and keep dust out. The system shown here has been successful in both vertical and horizontal applications in relatively clean surroundings.

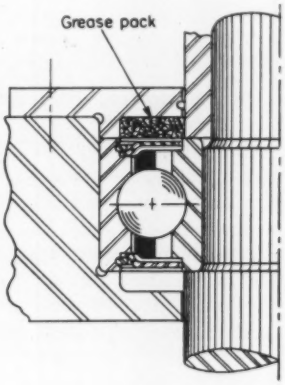


Fig. 7—Right—In this vertical shaft application using a double-shielded bearing, grease is packed between the upper cap and the bearing shield to supplement the original grease pack. Oil bleeds from the additional quantity as required.

ing the bearings and maintaining a constant low temperature, thus minimizing machining errors and prolonging bearing lubrication life.
2. Air pressure applied to the interior of the spindle effectively prevents entrance of foreign particles thus extending "smooth running" life of the spindle and maintaining accuracy of surface finish of work performed.
3. Bearings are constantly fed with an optimum quantity of oil, thus minimizing bearing heating due to lubricant churning.

The trend to the usage of this system is for speeds above about 600,000 *DN*. Many older types of spindles have been converted to this system because of the cited advantages. Water separators and filters for the air supply are essential, however.

WICK-FED AIR-OIL MIST SYSTEMS: Where equipment must be light in weight with minimum complication as in most turbo-driven aircraft accessory applications, the wick-fed air-oil mist system is widely used. Historically it is an adaptation and refinement of high-speed machine-tool spindle systems in common use as far back as 20 to 30 years ago. Essentially it consists of an oil sump from which oil is elevated by a wick or wicks to the rotating shaft. Windage of the rotating shaft blows the oil into a mist which is drawn through the bearings by outboard slinger pump members, Fig. 3. The following design precautions should be taken with this general type of system:

1. Wicks should be generous in cross-section and preferably used in pairs with each wick disposed as close to each bearing as possible.
2. Wicks should be arranged to have partial immersion in the fluid at all times.
3. Wicks may reabsorb oil thrown off shaft if too much wick area surrounds the shaft.
4. Viscosity of fluid lubricant must be such that wicks will feed oil at low temperatures even under low atmospheric pressure and reduced speed conditions.
5. Slingers must effectively pull oil mist through the bearing. Increased pumping is afforded by increasing diameter of slingers and adding vanes as necessary.
6. Minimize pressure differentials, so that bearings are equally lubricated. Use rubbing seals only in extreme problem cases since these further increase energy losses and heating.
7. Cool sump all possible and minimize temperatures by heat dams since the best lubricants may provide only borderline lubrication above 400 F.

VACUUM IMPREGNATION OF PHENOLIC BALL RETAINERS: This section would not be complete without a brief mention of one unique system of lubrication of moderate-speed bearings. This system involves what is known as vacuum impregnation of phenolic laminate ball retainers. So far, reliance on this system has been confined to sealed units operating in nonoxidizing atmospheres of helium and hydrogen at controlled temperatures of about 200F

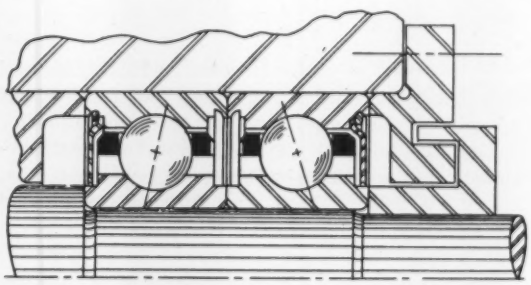


Fig. 8—Elimination of the shields on the abutting sides of this bearing pair provides extra volume for the initial grease charge. Thus, this is a self-contained prelubricated system, ready for use.

and speeds generally below a *DN* value of 200,000. The thin oil film resulting from this process is partially absorbed into the cotton-base phenolic laminate material which acts as a wick. Favorable factors include lack of oxygen, moderate temperatures and minimum windage effects tending to exhaust or dissipate the lubricant. Use of this system in normal atmospheres containing oxygen and under wide temperature fluctuations should be considered experimental, although the oil-impregnation process, coupled with further addition of grease has provided additional reliability.

Grease Lubricating Systems: Systems consisting of housings, caps, seals and slingers have been in general use for ball-bearing applications for many years. Designs most frequently needed and used with superprecision high-performance bearings will be reviewed. While relatively few high-speed applications today must be designed for more than a few hundred to a few thousand hours between overhauls, much critical damage to bearings will result if a few fundamental precautions and provisions are not given proper consideration.

The simplest form of enclosure is indicated in Fig. 4. Where dust or other contamination is expected, single or double-labyrinth enclosures, Fig. 5, may be required. Shielded superprecision bearings may also be employed for supplementary dust protection if desired. Longest lubrication life at elevated speeds is secured by using wide-series, double-shielded bearings as available, or single-shielded bearings in order to avail the designer of extra lubricant space within the bearing. Speeds up to 500,000 *DN* have been attained with double-shielded bearings with phenolic ball retainers using high-grade lubricants as long as temperatures are moderate, below about 200F.

Where the user will lubricate the bearing, it is

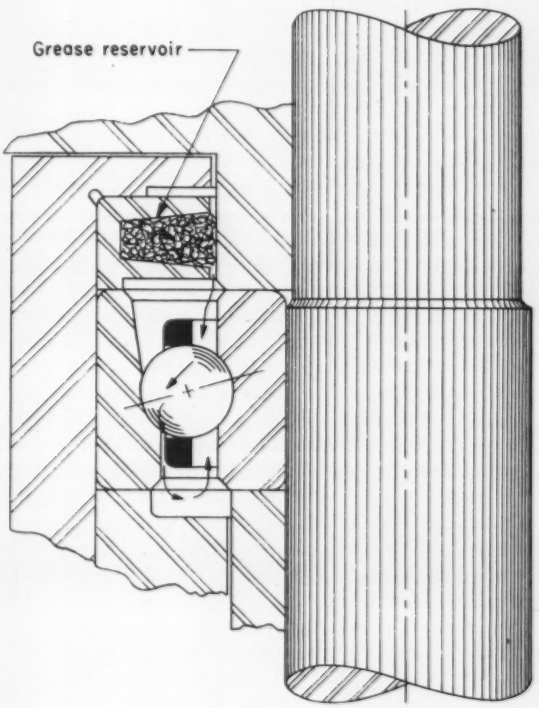


Fig. 10—Systems such as that shown here have worked very successfully at speeds to 600,000 *DN* at temperatures to 125 F. Oil bleeding from the grease pack drips down to lubricate the bearing.

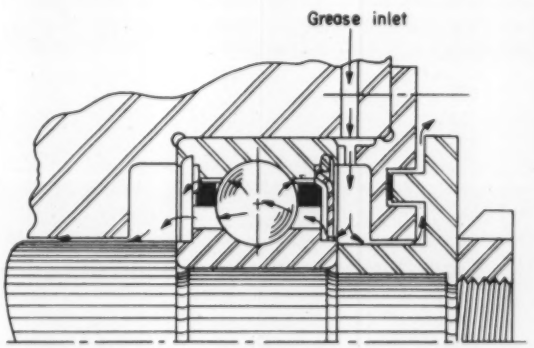


Fig. 9—When relubrication of a bearing is necessary, a single-shielded bearing may be used as a metering device. Applied as shown here, the shield prevents overlubrication of the bearing. Excess grease is forced out through the labyrinth and serves to seal the labyrinth passages.

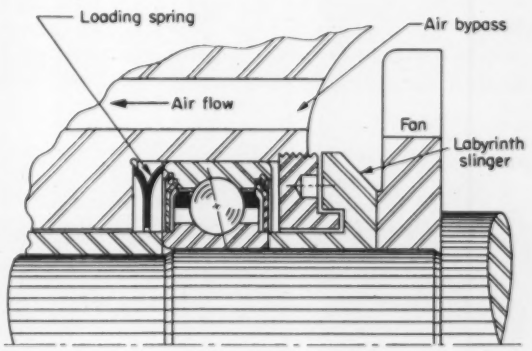


Fig. 11—The bearing design shown here has been successful in preventing grease migration due to air blast in small air-driven tools operating at speeds as high as 100,000 rpm. The air bypass tends to equalize pressures on both sides of the bearing and prevent grease migration and loss.

usually desirable to fill the free housing space about half full. Additional filling or packing will tend to cause higher initial temperature rise and may result in development of abnormal temperatures and even bearing failure.

Running clearances in labyrinth and shaft clearance seals vary with the design and depend largely on machining accuracy, shaft vibrational travel and need for avoiding frictional contact at high speed. Usual practice in noncritical applications is to use clearances of about 0.003 to 0.005-in. on a radius and somewhat more axially, depending on axial motion and tolerance accumulations.

Shielded bearings in a simple system, Fig. 6, have worked very well at speeds approaching 500,000 *DN*. In this case, use has been made of the slinger as a rotating baffle to prevent air flow and dust ingress. Use of this system has been confined to relatively clean surroundings, but with equal satisfaction horizontally or vertically.

In an application of a shielded bearing to a vertical shaft, Fig. 7, grease is packed between the upper cap and the bearing shield, thus supplementing the grease pack applied to the bearing originally. Additional lubrication is thus provided by oil bleed action from this supplemental grease quantity.

Superprecision, single-shielded, duplex preloaded pairs may be arranged for an initial charge of lubricant into the bearings, Fig. 8. Eliminating the shields on the abutting sides, provides extra volume for grease; thus, this arrangement is a self-contained system prelubricated and ready for use as supplied by the bearing manufacturer.

When relubrication must be supplied, a single-shielded bearing can be used to advantage as a metering device to avoid overlubrication of the bearings, Fig. 9. Application of new lubricant serves a dual purpose of purging out old lubricant and renewing sealing action by seepage through the labyrinth seal collar clearances.

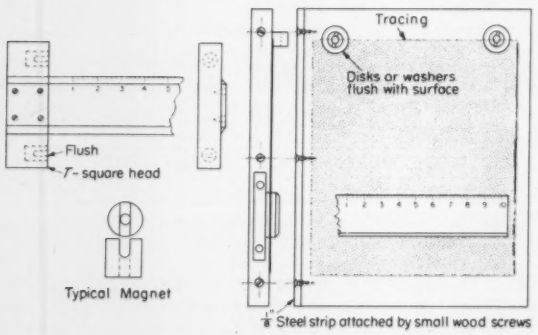
Vertical shaft bleed systems, Fig. 10, have been used with outstanding success at speeds up to about 600,000 *DN* under ambient temperature conditions of about 125F maximum.

Preventing Lubricant Starvation Due to Air Flow: Numerous instances have arisen in connection with small air-driven tools, which run at speeds up to about 100,000 rpm, where the air blast has caused grease migration and loss to such an extent as to cause bearing failure within a few hundred hours or less. Reduction of air flow has materially improved bearing life under such conditions. A careful check of relative pressures within and without bearing housing spaces will usually confirm this condition and lead the way to a proper redesign solution. Lubricant starvation with double-shielded bearings on electric-driven tools has also appeared in a few cases. One design solution to this problem is indicated in Fig. 11.

Tips and Techniques

Using Small Magnets

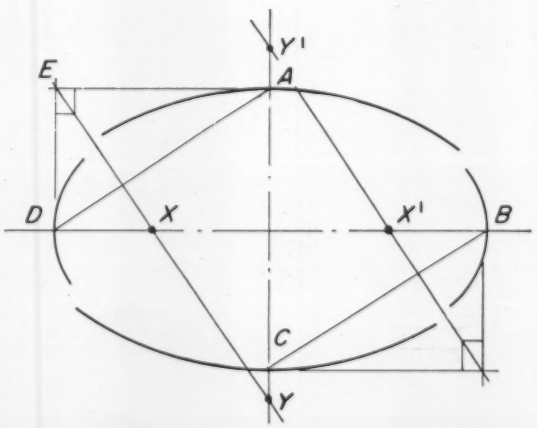
Small cylindrical magnets can be used to hold small tracings and drawings to the board and permit quick, correct positioning when revisions are necessary. Small disks or washers are embedded in the board and the small magnets are placed atop the tracing to hold it between disks and magnets.



These small magnets may also be used to maintain a firm contact between T-square head and drawing board edge as shown in the sketches.— RAY BEAL, *Los Angeles, Calif.*

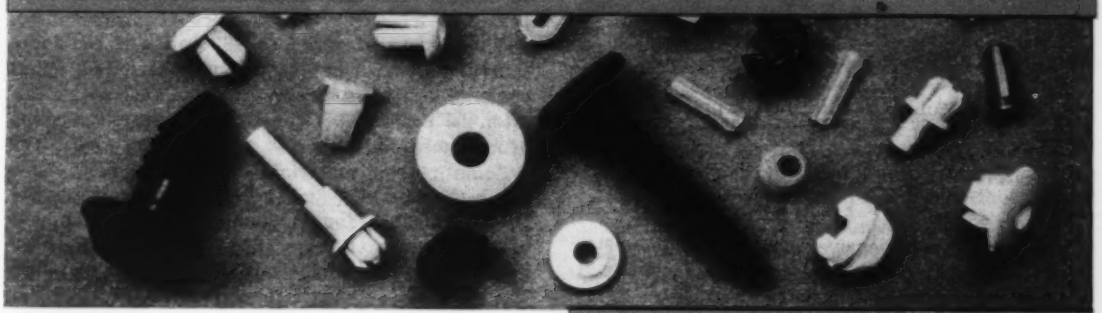
Drawing Ellipses

To construct an ellipse quickly after the axes *AC* and *BD* are drawn, construct a perpendicular to *AD* through *E*. The points *x* and *y* are then used as centers for the arcs shown. Since the radii do not meet, as shown, they must be joined with a French curve. — ALFRED BECK, *Convair Pomona, Pomona, Calif.*



When and where to use
Molded Plastic Fasteners

By W. R. Black, *Chief Engineer*
Fastex Div., Illinois Tool Works, Des Plaines, Ill.



A brief report on advantages and disadvantages, materials, cost, and future of fasteners and combination units made from molded plastics.

PLASTIC fasteners have found their place in industry. In many applications, they can do a job metal fasteners cannot accomplish. However, plastic fasteners are a relatively new design area, one which is still primarily trial and error.

Advantages: As a guide in selection, the natural characteristics of the basic material should first be recognized.

Corrosion Protection: Plastic needs no plating or finishing for corrosion protection. A good example is a plastic grommet, Fig. 1, for mounting the balancing ring on the interior of automatic washing machines. The assembly is exposed to a detergent solution, and one of the most stringent requirements is the fastener's ability to stand up in the solution. The interior of refrigeration equipment is also subjected to very moist conditions, and here too plastic fasteners have found a natural application.

Color Matching: Plastics are readily and easily

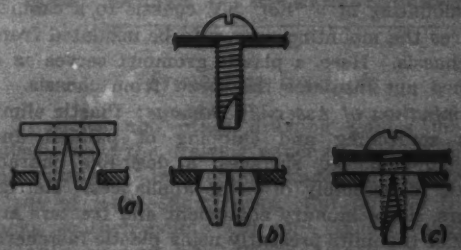


Fig. 1 — Molded plastic grommet acts as a front-applied nut, *a*. Finger pressure snaps it into the hole, *b*. A thread-cutting screw, *c*, forces the prongs apart and taps the hole.

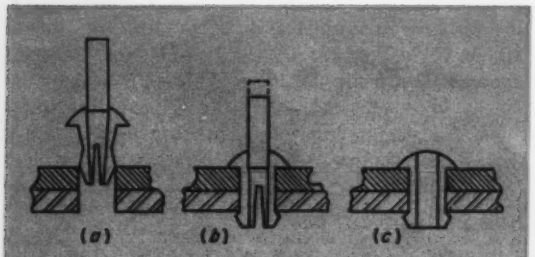


Fig. 2—A plastic rivet is pressed into the hole, *a*. The central, integral pin is forced home, *b* and *c*, by a hammer blow, locking the rivet in place.

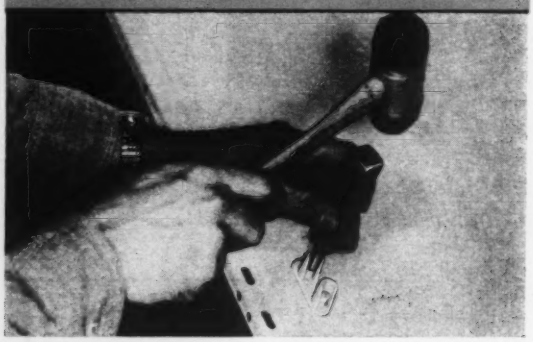


Fig. 3—Molded plastic shelf support for a refrigerator combines plastic rivets with the support. Easy assembly is the prime feature of the unit.

color matched. Expensive "camouflaging" operations are not needed to cover up the fastener; it can be colored to match or harmonize with its surroundings.

Insulation: Plastics are good electrical and thermal insulators. In some assemblies one unit must be insulated from another. Such is the case in the attachment of a component strip in a TV tuner. A one-piece plastic rivet, Fig. 2, accomplishes the purpose without the insulating bushings and washers needed with a conventional metal fastener. The mounting of a "hot" TV chassis to a cabinet requires the mounting screws to be insulated from the chassis. Here, a plastic grommet serves as a retained nut insulates the screw from chassis.

Elimination of Assembly Damage: Plastic eliminates scratching and chipping of painted and porcelain-enameled surfaces, a desirable characteristic in assembly of home appliances. Refrigerators, home laundry equipment and freezers are a few of the units presently using plastic fasteners.

Sealing: When a plastic fastener is mounted in its final position, the material will yield sufficiently over minor surface imperfections or small burrs to seal. It will not effect a high-pressure seal. But where the primary sealing is to keep out rain, as in automotive trim attachment, or to provide a vapor seal in refrigerators, it is an excellent solution to the problem.

Multiple-Function Units: Since plastic fasteners are usually molded, intricate shapes and forms, as well as variations in cross-sectional areas, can be readily reproduced. The designer can, in many cases, combine two or three parts into one unit, with an end cost substantially lower than the original group of parts. Such is the case in the plastic shelf support, Fig. 3, where stainless steel and plastic were redesigned into an all-plastic unit. The resultant cost savings are as high as 30 per cent in total cost of purchased parts and assembly.

Disadvantages: Some conditions where plastic fasteners are at distinct disadvantage are:

1. Temperature requirements over 350 F.
2. High stress or shear requirements.
3. Where piece cost as such is critical.

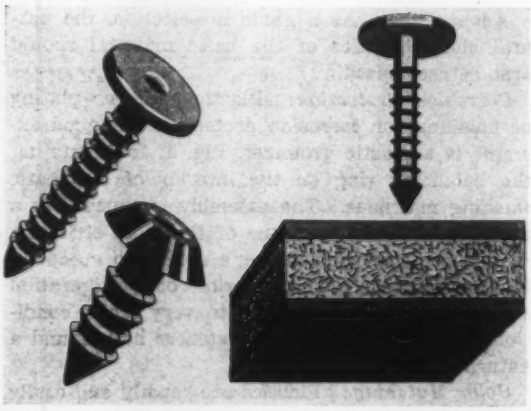
As new materials are developed and production techniques are further refined, these factors will become of less significance.

Selection of Plastic: Millions of metal fasteners are used each day solely because of ease of handling. Small subassemblies are attached with relatively large metal fasteners because they are easy to handle. The end result is a 2 to 5-lb unit supported with four or six fasteners which, combined, will carry a load of 2000 to 3000 lb. If the function to be performed is carefully reviewed, small parts of the subassembly and the fastenings can often be combined. Frequently, substantial sums of money can be saved.

Some plastic materials, such as polyethylene, are very flexible, and other factors also make them desirable for fasteners. The attachment of the insulation material to the firewall of an automobile is an application illustrating this point, Fig. 4. The fastener is simply pushed into place.

When selecting a plastic fastener, utilize the natural characteristics of the material:

Fig. 4—Headed push-in type plastic fasteners attach the insulation material to the firewalls of cars and trucks. Besides providing an easy method of assembly, the fasteners also seal against entry of water.



Nylon: Excellent strength; resists heat well; good up to 350 F.

Polystyrene: Low in cost; lower in strength than nylon; good up to 160 F.

Polyethylene: Low in cost; medium-strength material; good insulator; "rubber-like" characteristics; good up to 190 F.

Vinyl: Good elasticity; good resistance to chemical corrosion; used in specialty applications.

These materials are the most popular in today's fasteners. They are readily molded, and do a good all-around job.

Probably the most promising and versatile plastic is nylon. It has many features found in other materials plus the ability to withstand temperatures up to 350 F. It is tough and stands up well under fatigue. These characteristics have given it broad application in the fasteners.

Many engineers rightfully question the performance of a plastic fastener after "cold flow" takes place. It is true that all plastic materials undergo some cold flow. However, the newer materials, such as nylon and Teflon, are excellent in this respect. Fig. 5 is a total deformation versus time curve for various loadings on Du Pont Zytel 101 nylon. It is apparent that most of the deformation occurs during the first 75 hr of loading. Even at the higher loadings, the percentage change due to cold flow is small when one considers the job being done. A knowledge of the material, plus experience in working with it, determine the ultimate success or failure of the application.

Cost: Another factor which influences selection is cost of tooling. A typical production mold will cost a minimum of $3000 to $5000. To justify this investment, usage of parts must be high enough to keep the tooling cost per unit low. Design and construction of molds requires a high degree of skill and experience. Mold shrinkage is partially compensated for by initial calculation, but the unusual cross-sectional areas found in the newer plastic fasteners are difficult to calculate accurately. Experience is needed.

Each special application also requires sampling and testing both by the fastener producer and the ultimate user. This initial cost with present sampling methods is relatively high. Typical single-cavity sample mold expense will exceed $400, with many jobs requiring two or three attempts before a functional design is produced. It is not unusual for a new plastic fastener to swallow up $800 to $1000 before it is ready for final user testing. This factor further illustrates the need to select the proper application, choose the proper material, and weigh the economics of the project before proceeding.

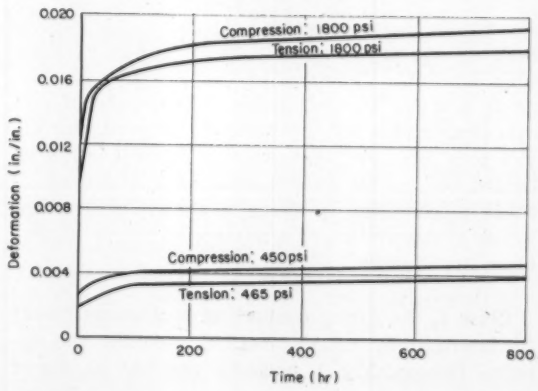
The Future Outlook: The advantageous characteristics of the plastic must be used to make the application a complete success. To convert a fastener directly from metal to plastics is usually not satisfactory. Unless there are inherent problems in the use of the metal, the cost cannot usually be justified.

Combining other parts with the plastic fastener can lead to substantial cost savings for the user. The opportunities offered in the mold to vary cross section and produce intricate shapes opens a completely new horizon for fasteners.

Plastic fasteners in commercial use today vary from straight material conversion (nuts, bolts, cable clamps, etc.) to units which perform as a fastener and have an additional function as well.

The industry is a dynamic one. Its limits at this time are unknown, for developments of new and improved materials are making many more things possible. The future largely depends on the development of new materials at considerably lower cost, for the mechanical limitations of the available materials and their cost are now the restricting elements.

Fig. 5—"Cold flow" effects on nylon show that most deformation occurs in the first 75 hr. Data are for Zytel 101 conditioned to average air exposure.



Tips and Techniques

Preventing Ink Blots

Triangles and other drawing guides may be raised above the drawing paper to prevent smudging because of ink running under an edge by the heads of large thumbtacks. Cut off the thumbtacks, so their points will not extend through the triangle or template. Then drill holes slightly smaller than the diameter of the tack pin and force the thumbtacks into the holes.—GENE J. KRYSKO, *Dole Valve Co., Chicago, Ill.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

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Fig. 1—Five-station external Geneva.

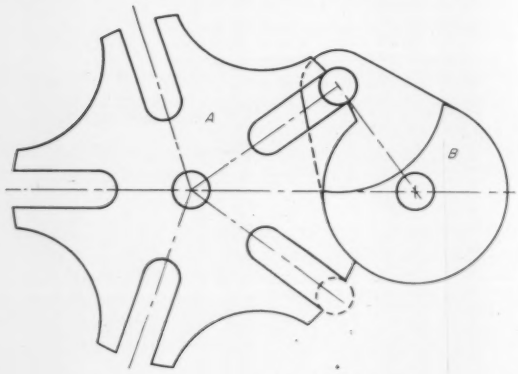
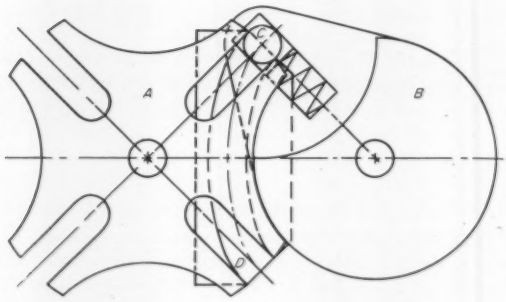


Fig. 2—Four-station external Geneva with spring block and cam path.



A PAPER FROM THE
THIRD CONFERENCE ON MECHANISMS

A survey of INTERMITTENT-MOTION

By F. J. Bogardus, *Associate Professor of Mechanical Engineering*
Purdue University, West Lafayette, Ind.

TRYING to define an intermittent-motion mechanism is somewhat like trying to define an automobile. Everyone knows what one is; yet there are gradations from the motor scooter through the "hot rods," the sport cars and everyday passenger cars, to the giant earth-moving vehicles of today. We all know what intermittent motion is; yet, if we are not careful, we shall be including all mechanisms with varying motion.

Let us limit the definition, and discussion, to mechanisms which produce alternate periods of motion and rest, with no reversal of direction in the output motion. This will exclude a great number of mechanisms which produce reciprocating or oscillating motion for their output, but will not exclude their use as motivating devices for intermittent-motion mechanisms.

With this limitation in mind, we may examine the possible combinations of motion and then classify various applicable mechanisms in accordance with these classifications.

It appears that the originating motion may be rotary or straight-line, continuous in one direction or reciprocating (oscillating). The output may be rotary or straight-line intermittent motion. The sum of all this is to provide eight classes or groups of mechanisms for the production of intermittent motion, Table 1.

Table 1—Intermittent-Mechanism Classification

Class No.	Input Motion	Output Motion
1	Rotary continuous	Rotary intermittent
2	Rotary oscillating	Rotary intermittent
3	Straight-line continuous	Rotary intermittent
4	Straight-line reciprocating	Rotary intermittent
5	Rotary continuous	Straight-line intermittent
6	Rotary oscillating	Straight-line intermittent
7	Straight-line continuous	Straight-line intermittent
8	Straight-line reciprocating	Straight-line intermittent

Some of the most familiar mechanisms fall into class 1: The external and internal Genevas, the starwheels, planetary gears with cam actuation. In fact, as one might suspect, there are many solutions available for some of the classes and relatively few for the remainder. The change of certain proportions may also transfer a particular device to a different classification. While it is not intended to provide here a detailed analysis of all these mechanisms, perhaps a sketch and a few words of description of a number of representative types are in order.

Class 1, the group converting continuous rotary to intermittent rotary motion, includes the external Geneva, Fig. 1, probably the best known of

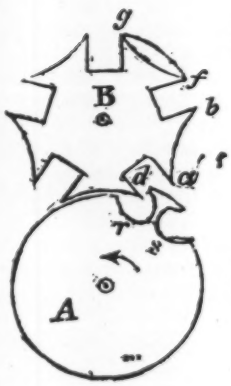


Fig. 3—Left—Geneva stop (Willis, 1846).

Fig. 4—Right—Five-station internal Geneva.

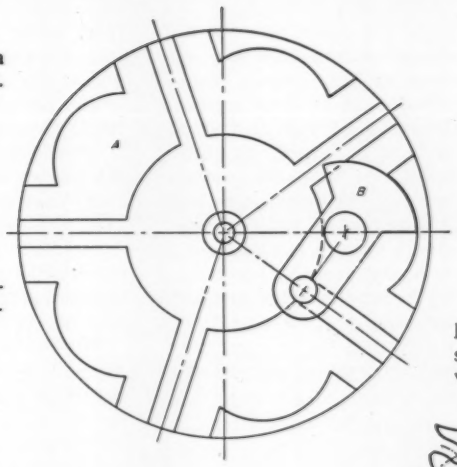


Fig. 5—Below—Two-station external star-wheel.

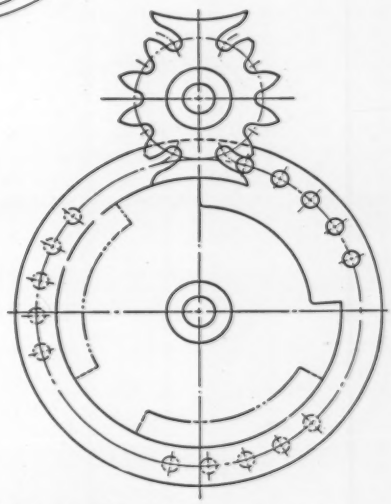
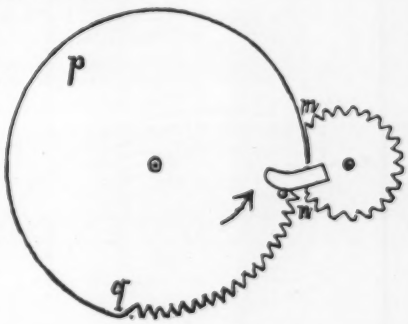


Fig. 6—Gear-tooth star-wheel (Willis, 1846).



MECHANISMS

the group. With a minimum number of stations or slots in the driven wheel but no maximum, with the number of rollers on the driver varying from one to six, and with variations in the spacing of the rollers and slots possible, it becomes a rather adaptable mechanism. However, for a given number of slots and center distance all relevant dimensions and kinematic relations are fixed. Furthermore, the ratio of duration of motion of the driven member to that of the constant-speed driver is always equal to or less than one, except for three stations. The angular acceleration varies from a maximum of 31.44 rad per sec^2 for three stations to a minimum of zero for an infinite number of stations, for a base driver speed of 1 rad per sec.

It is possible to reduce the number of slots in the driven member to two, provided a spring block arrangement is substituted for the fixed pin on the standard driver. However, this may run the acceleration as high as 54 rad per sec^2 for a driver speed of 1 rad per sec. The use of a cam path for the indexing roller in conjunction with a spring block can reduce somewhat the maximum acceleration of the standard Geneva, Fig. 2.

Of interest is an early form known as the Geneva stop, Fig. 3, which was used in the mechanisms of the Geneva watches in the first part of the 19th century.

The internal Geneva, Fig. 4, transmitting the same sense of rotation, is somewhat more limited in its application by the restriction of the number of rollers on the driver to one. This arises from the fact that the motion of the driven member occupies more than one-half revolution of the driver. Since the dwell period is always less than one-half revolution, the maximum acceleration of the driven member is much less than that of the

external Geneva, being on the order of 1.73 rad per sec^2 for a driver velocity of 1 rad per sec.

Some of the limitations of the Geneva mechanism can be overcome by the use of the starwheel mechanism, Fig. 5. Here the partial movement of the driven shaft can be a full turn, or more. The driver is equipped with at least two rollers for accelerating and retarding the driven member, while intermediate rollers impart a uniform motion. In fact, involute teeth can be used in place of the rollers and slots, except for the accelerating and retarding slots. A considerable variation in maximum acceleration results from variations in the ratio of driver to driven radii. Appropriate modifications to the basic starwheel idea in the form of a control roller on the driven member and a control cam on the driving wheel can improve the acceleration characteristics.

The principle of the starwheel, gears with some teeth removed, has been known for many years. It was described and illustrated in *Principles of Mechanism* by Robert Willis 115 years ago, Fig. 6. Note the use of an auxiliary pin and guide plate to insure proper engagement of the first two teeth.

Internal starwheel mechanisms, Figs. 7 and 8, offer little advantage over the external starwheels except compactness of the drive and the elimination of the intermediate rollers in some cases.

Where the shafts are intersecting instead of parallel, bevel gears, Fig. 9, can be used. Kinematic properties limit such combinations to slow speeds. Here, too, the Geneva idea can be used. The spherical Geneva mechanism, Fig. 10, provides motion and dwell of the driven member over 180-degree periods of rotation of the driver. The use of two rollers will reduce the dwell period to zero.

If the shafts are skewed (nonintersecting) other combinations such as the concave cam and roller follower may be used, Fig. 11. Such a combination can be designed to impart any desired motion to the driven member, such as simple harmonic, cycloidal, constant acceleration and deceleration. The number of rollers on the follower, and

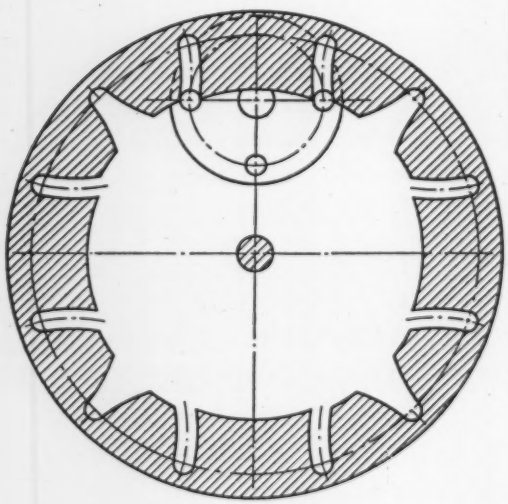


Fig. 7—Four-station internal starwheel (driver smaller than driven wheel).

Fig. 8 — Two-station internal starwheel (driver larger than driven wheel).

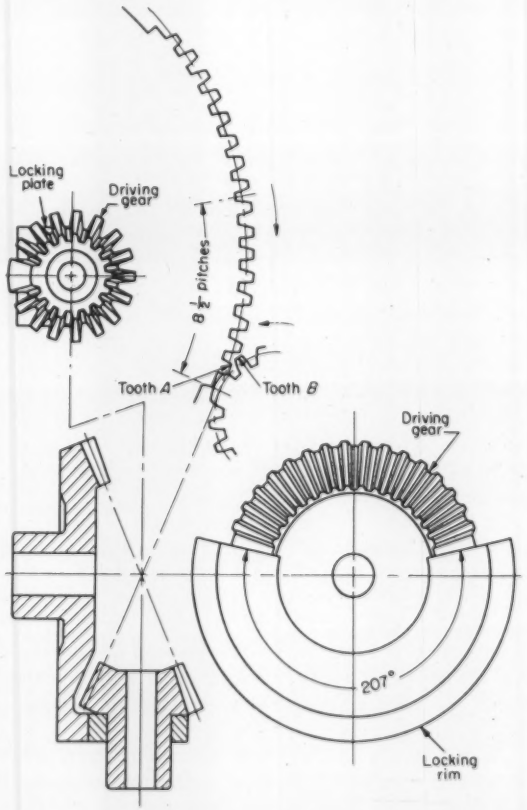


Fig. 9—Intermittent-motion bevel gear.

hence the number of cycles of motion of the driven member, will depend upon the amount of envelopment of the follower circle by the cam. The minimum practical number of stations for this combination is three. If the followers are placed in the face of a mating disk, then a drive such as shown in Fig. 12 is obtained.

Another ingenious device for producing a momentary dwell in the output is shown in Fig. 13. If the crank and arm are of suitable proportions, the crank will come to a stop once each revolution when the pin P reaches the point C. A shorter crank will cause a reversal, while a longer crank will eliminate the complete stop. Thus, this mechanism is not as versatile as the previous devices, since it is limited to one stop per revolution of the driver crank.

Several mechanisms using planetary gears with some form of control on the motion of the cage or of one of the sun gears have been devised. Fig. 14 shows an internal planetary system with rack and scotch yoke control mechanism. With proper proportions for the crank C and cage gear F a condition of zero velocity for the output sun pinion once each revolution of the driving gear B can be obtained. A modification of this system to avoid some of the sliding action is seen in the use of a quadric crank control instead of the scotch yoke. A deviation from the simple-harmonic motion produced by the scotch yoke may be expected.

A further modification employs a fixed eccentric and sliding rack control, Fig. 15. A rack B fastened to a rotating flywheel A through pin E engages output pinion S_1. The strap or connecting link D is constrained to turn around the stationary shaft F and thus causes the rack to slide back and forth in the slot C. If the distance OO_1 between the centers of the stationary and flywheel shafts is equal to the output pinion pitch radius, a condition of zero velocity is reached once each cycle of the output pinion.

Another variation employs an oscillating external gear segment to replace the rack.

Still further variations may be obtained by the use of a cam-and-follower-actuated rack to vary the motion of the planetary gear cage. Thus, the use of suitable gearing could provide more than one stop for each revolution of the output pinion.

Several rather simple gear drives make suitable intermittent-motion mechanisms. A worm given axial motion as well as rotation, Fig. 16, will drive the gear with a variable speed. Correct cam profiles will produce one or more dwell periods for each revolution of the input shaft.

For parallel shafts, helical gears can also be made to provide an intermittent motion by giving an axial motion to the driver with proper cam and follower. Such arrangements create problems as-

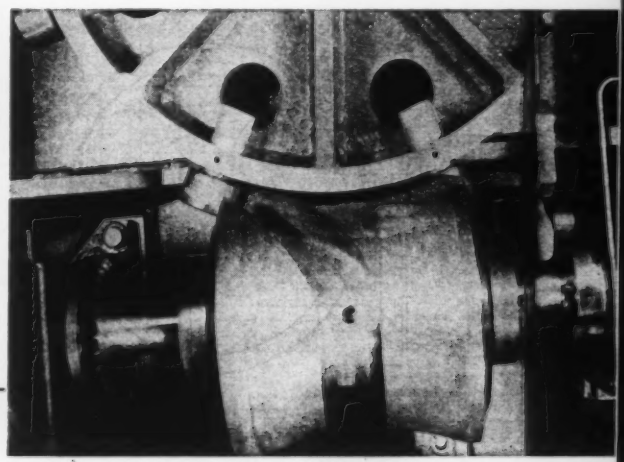


Fig. 11—Concave cam and roller follower.

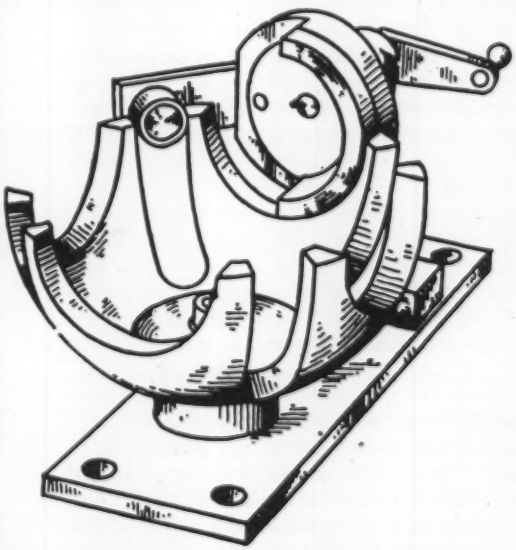


Fig. 10—Spherical Geneva.

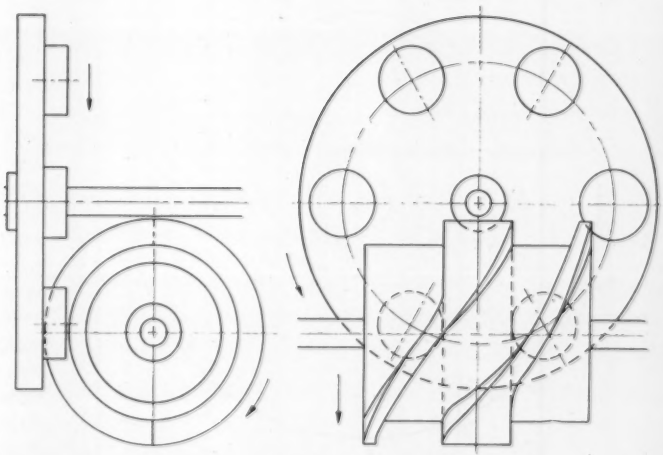


Fig. 12—Cam indexing mechanism.

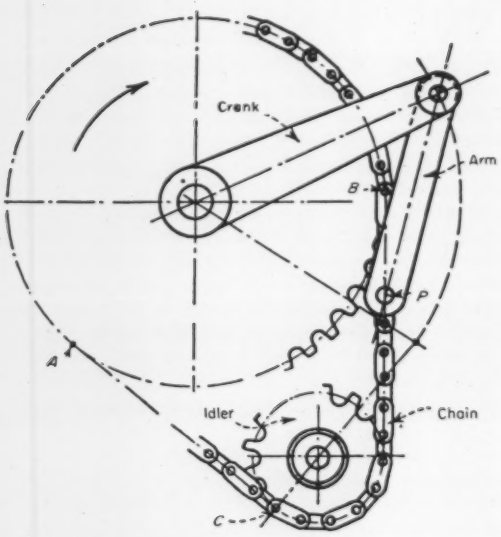


Fig. 13 — Chain-driven intermittent-motion mechanism.

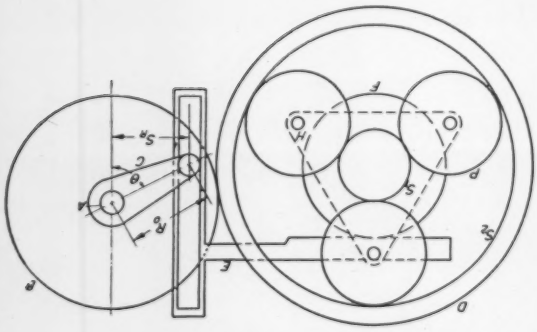


Fig. 14—Internal planetary-gear system with rack and scotch-yoke control.

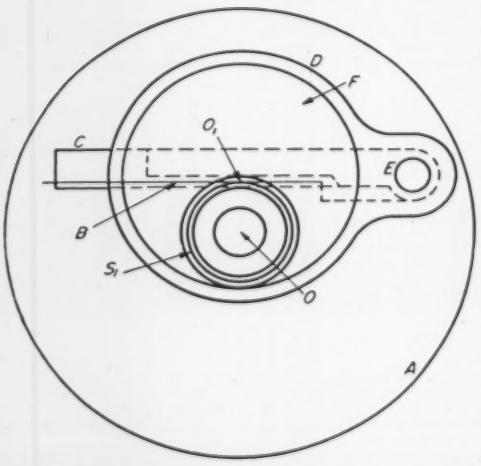


Fig. 15—Fixed eccentric and sliding-rack control mechanism.

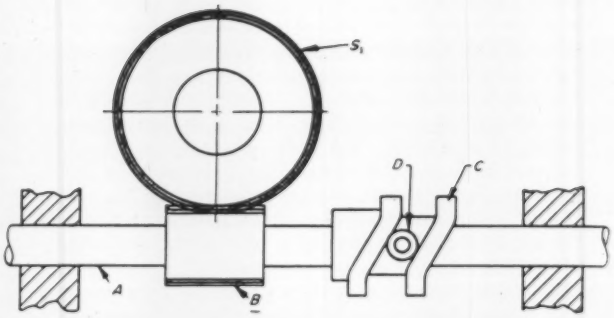


Fig. 16—Worm and gear with cam control.

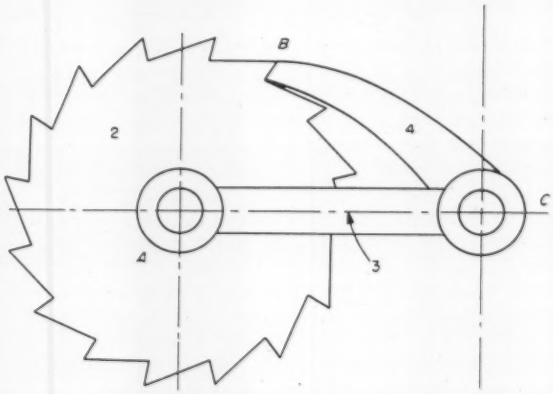


Fig. 17—Simple ratchet wheel and pawl.

sociated with the sliding motion of the driving shaft.

Class 2, rotary reciprocating (oscillating) driver with rotary intermittent driven member, immediately suggests the simple ratchet, Fig. 17. It may be constructed as an internal or an external ratchet. The use of two pawls and an oscillating lever permits two driven strokes for each complete oscillation of the driver, Fig. 18. This principle may be applied whether the shafts are parallel or intersecting.

The manner of producing the oscillating motion is in itself a subject of considerable interest. There are numerous combinations of linkages, cams and gears available to create the desired oscillation. Some of the intermittent motion mechanisms already mentioned can themselves be used for such purposes by altering the proportions of certain members.

Instead of the use of pawls, the so-called "silent" ratchets may be considered. These, working upon the principle of wedging rollers or balls in tapered slots, or wedging eccentric blocks or "sprags" in uniform-width slots, provide smooth quiet action. Fig. 19. Backlash is reduced to a minimum by the use of springs to maintain continuous contact between the elements and both sides of the slot.

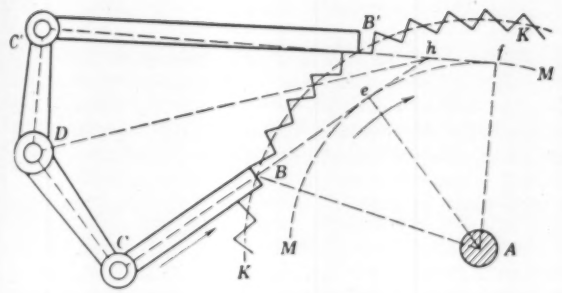


Fig. 18—Double-acting rotary ratchet.

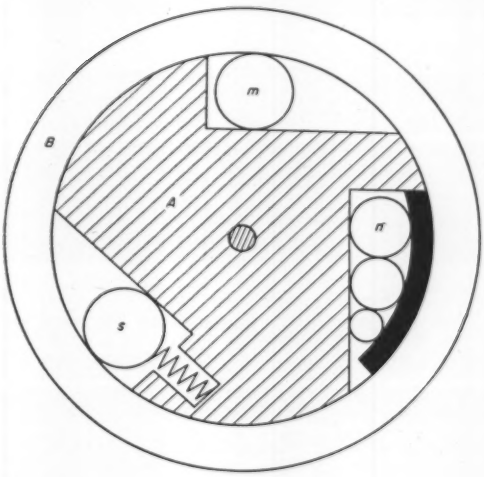


Fig. 19—Silent ratchet.

The wedge and disk type of mechanism, Fig. 20, is subject to a number of variations. Here motion of the lever *D* counterclockwise about pin *E* causes wedging between the end *F* of the lever *D* and the groove *G* in the ring *C*. Continued rotation of *D* thus forces rotation of shaft *A* to which *C* is keyed. A hardened node *H* limits the relative motion of *D* and *B* in the reverse direction by bearing against the bottom of the groove *G*. This arrangement may be replaced by a toggle link and disk, Fig. 21, spring-backed sliding pin or roller, rocker arm and disk or other combinations.

Class 3, straight-line continuous to rotary intermittent motion, contains the counting devices. A rotating counter is engaged by the items carried on a chain conveyor, or by projecting fingers from the links themselves. At least three stations or pins are normally required on the driven member, although a spring block and cam arrangement could permit the use of two stations.

The starwheel mechanism, using an infinite radius for the driver provides a mechanism of this type. Either one or two dwell periods of arbitrary length per revolution of the driven shaft can be obtained, Fig. 22.

Class 4, straight-line reciprocating to rotary intermittent motion, is exemplified by the ratchet mechanism with infinite radius driver. Pawls on two sides of the ratchet wheel, Fig. 23, create semicontinuous motion with only momentary dwell periods for the driven ratchet wheel. Instead of toothed elements, the silent ratchet idea may again be used. One hindrance to this device is the curved path that the friction elements must follow if the stroke of the driver is of appreciable length. To

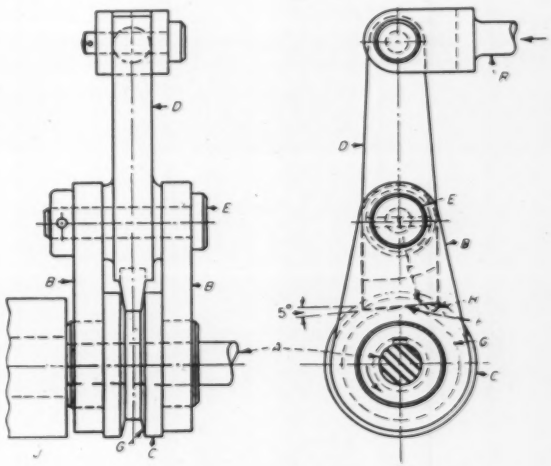


Fig. 20—Wedge and disk device.

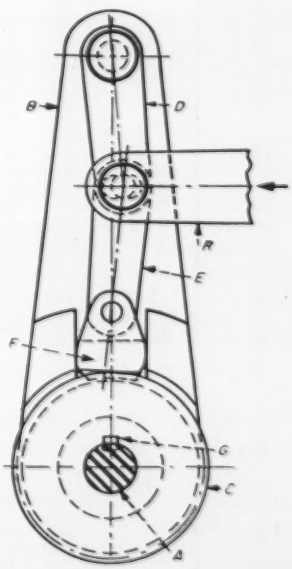


Fig. 21 — Toggle link with wedge and disk.

some extent this can be overcome by mounting the rollers or balls in blocks which can themselves slide in a transverse direction relative to the reciprocating member.

Classes 4 to 8 might be questioned with respect to whether they are really necessary. In almost every case the mechanisms previously described will fall into one of the last four classes if the radius of the driven member is increased to infinity. However, since the radii of rotating members usually fall within a comparatively narrow range and since straight-line motion is of considerable special interest, it seems well to provide for these four groups.

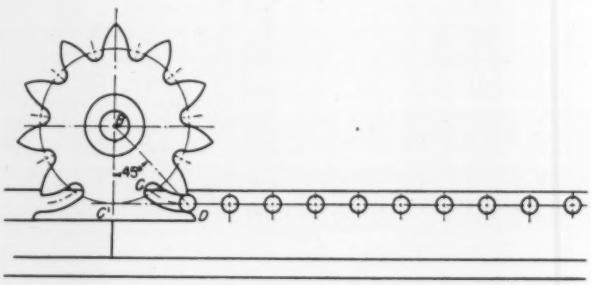


Fig. 22—Starwheel with infinite-radius driver.

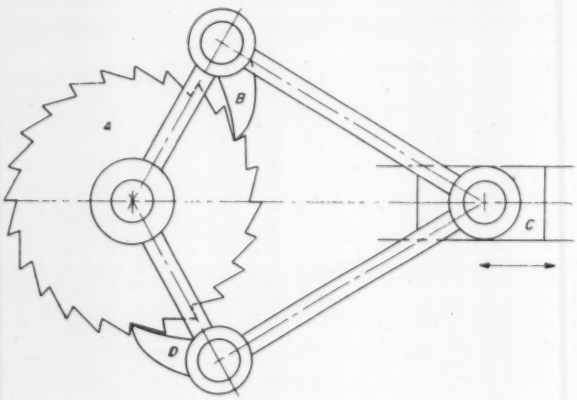


Fig. 23—Straight-line to rotary semi-continuous-feed ratchet.

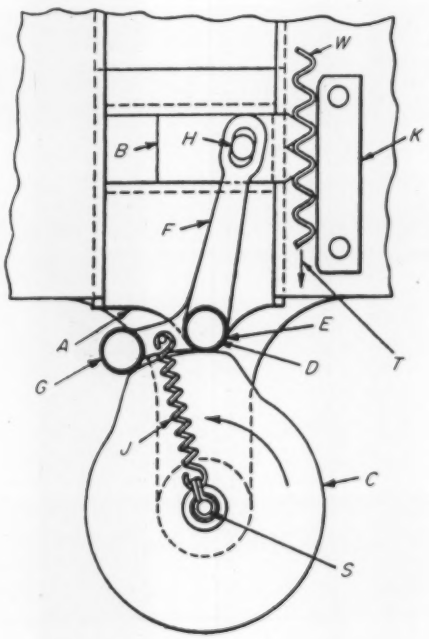


Fig. 24—Double-slide intermittent-motion mechanism.

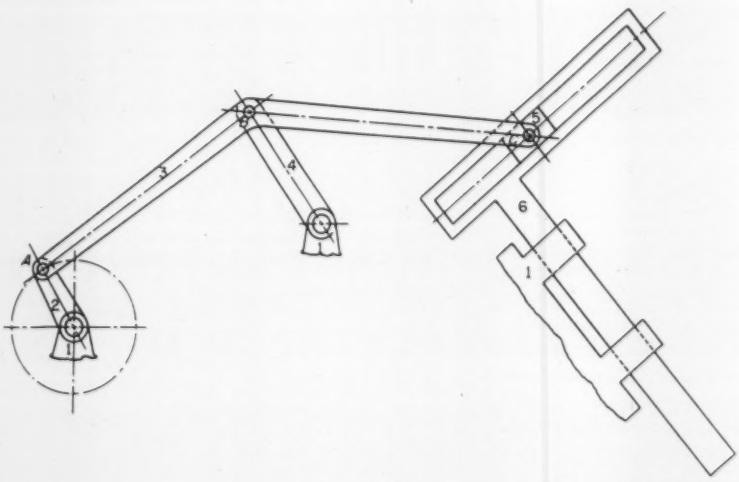


Fig. 25 — Four-bar linkage driving straight-line intermittent motion.

Other intermittent mechanisms, perhaps, do not fall exactly within the eight classes listed in Table 1. For example, in a wire cloth advancing mechanism, Fig. 24, the driver passes through a cycle controlled by a double cam acting through followers with tangential motion and with radial motion to move the double slide. While the teeth of the driver follow a curvilinear path, they move with essentially straight-line motion while engaged with the cloth. The standard four-bar linkage, Fig. 25, also can produce the necessary approximate straight-line motion through a portion of the cycle to drive either rotary intermittent or straight-line intermittent-motion devices, classes 4 and 8.

Another group of devices that merits mention is that of the escapements. But closer examination indicates that most of these can well fall into classes 2, 4, 6 or 8. Here, generally, the relation of driver and driven is changed. Thus, an oscillating double pawl permits intermittent rotation of a ratchet subjected to a turning moment.

It is not possible in this brief survey to mention all intermittent-motion mechanisms, nor would it be desirable to attempt to do so. Those who seek more detailed information on such devices are referred to such sources as those listed in the accompanying Bibliography.

ACKNOWLEDGEMENT

Illustrations in this article from other sources are listed in parentheses in the accompanying Bibliography. The author is indebted to each of the so noted publishers for permission to reproduce the illustrations here.

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This article was presented as a paper at the Third Conference on Mechanisms, Purdue University, May 24-25, 1956. The Conference is cosponsored annually by the Purdue School of Mechanical Engineering and MACHINE DESIGN.

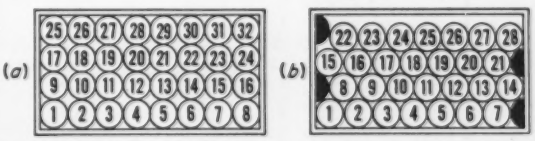
Tips and Techniques

Report Form

When reports such as progress reports are required at frequent intervals much time can be spent keeping the reports up to date and making copies of them. Savings in time and effort can be effected by first ruling the necessary form on one side of a lightly sandblasted (both sides) sheet of plastic film. Then the required information is filled-in on the reverse side of the sheet. As soon as the ink has dried, as many copies as necessary can be made on a black and white printer. When changes are necessary, a damp eraser will remove the lettering with no effect on the ruling on the reverse side of the sheet.—M. W. ELMENDORF, *Penfield, N. Y.*

Storing Tracings

When tracings are rolled in long tubes and stored in open racks, *a*, removal of a tube from



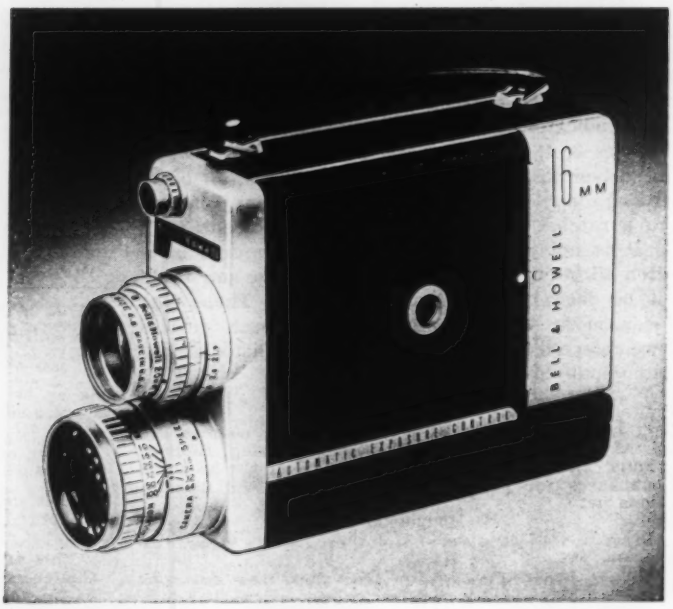
one of the lower racks will result in some of the upper tubes becoming disarranged. By cutting two tubes in half and gluing or otherwise fastening them into the rack and then arranging the tubes as shown at *b*, all other tubes will remain in place when one is withdrawn.—FRED J. PARONE. *Cochrane Corp., Philadelphia, Pa.*

Eradicating Lines

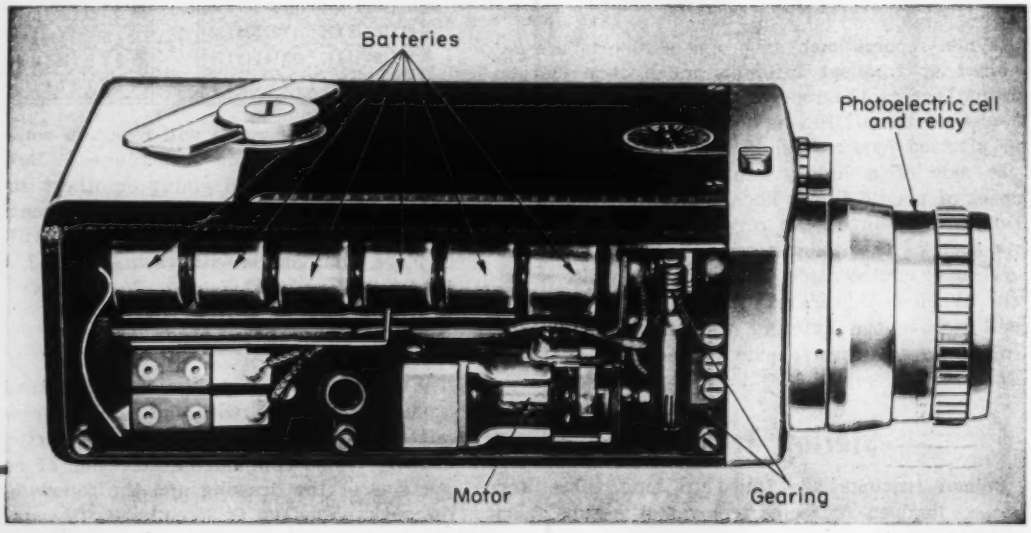
A small camel's hair brush used instead of the applicator supplied with ink eradicator will permit removal of very small lines or sections of a drawing. This eliminates eradication of necessary portions of the drawing and the following touch-up work.—EDWARD O. FERDINAND, *Chicago, Ill.*

Automatic Diaphragm Used On MOVIE CAMERA

FULLY automatic setting of the iris diaphragm to provide correct film exposure has been incorporated in the 200 EE, 16-mm movie camera recently introduced by Bell & Howell Co. Not only does the system eliminate the need for transferring calculated exposure settings to camera controls, but it will also adjust diaphragm opening continuously during actual filming if light conditions are changing. The camera and exposure-adjusting system function at speeds of 16, 24, 32 and 64 frames per second using films with ASA speed ratings from 10 to 100.



Control system components are all integral parts of the camera. Light from the direction of the subject to be photographed first strikes a reticular lens and then passes through a baffle to a photocell. Purpose of the baffle is to prevent erroneous diaphragm settings because of lighting conditions in areas other than that to be photographed. The photocell gen-

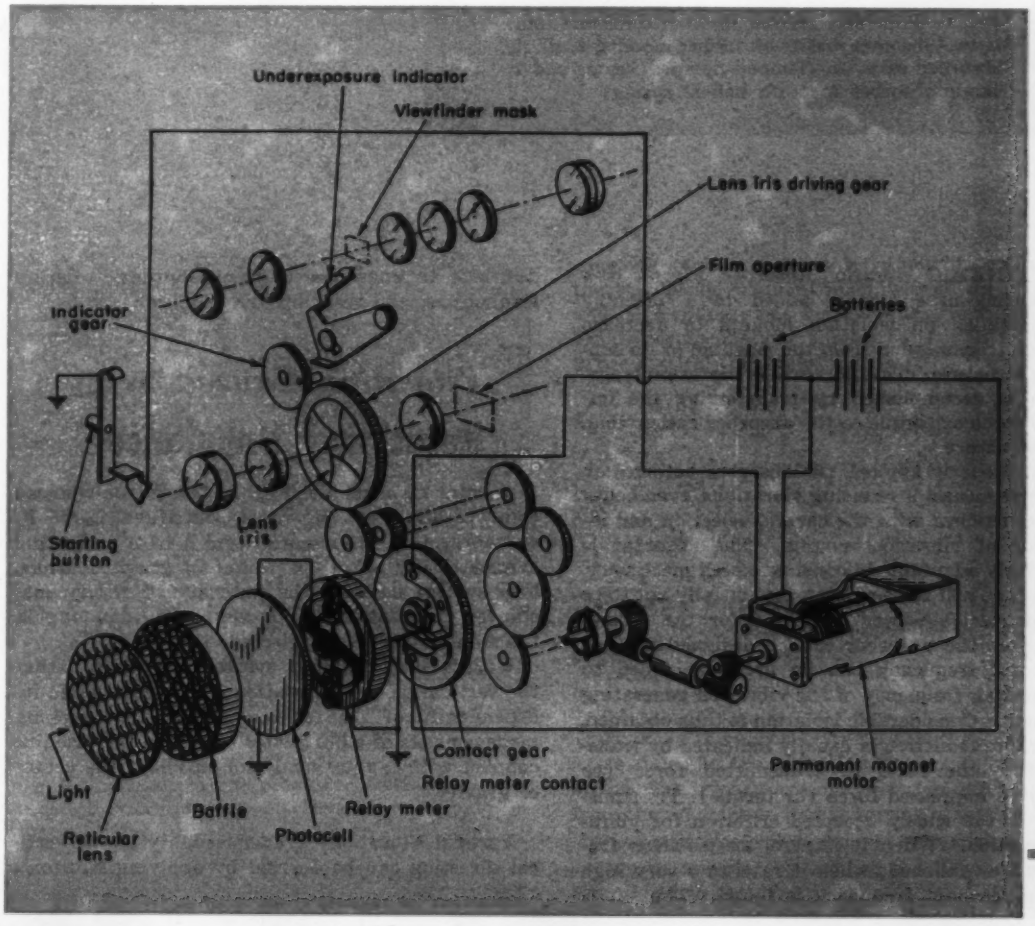


erates a small electric current which is proportional to the amount of light striking the cell. This current is then used to deflect a meter relay. Assuming that the diaphragm setting is not correct, movement of the meter relay contact causes it to contact one of the two contacts on the contact gear. This will then complete a circuit through one or the other set of batteries, the motor and the starting button when it is depressed.

The motor then drives a gear train which includes the contact gear and the lens iris driving gear to correctly adjust the diaphragm and move the contact gear until neither of the contacts on the gear touches the meter contact. Direction of motion is determined by which of the contacts on the contact gear is in the circuit since each of these contacts corresponds to one of the battery sets, which have reverse polarities.

A small pin on the indicator gear contacts the underexposure indicator to swing a small red flag into the view-finder field and warn the camera operator when there is not sufficient light to expose the film correctly. The camera is designed so that the starting button is pressed inward to complete the iris adjusting circuit and down to start the film transport mechanism. This allows correct setting of the diaphragm before any film is exposed.

Because current is drawn from the batteries only while the iris is being adjusted, life of the six tiny mercury cells is said to be one year minimum. Retail price of these cells is approximately $3.00.



Analytical

Dynamic

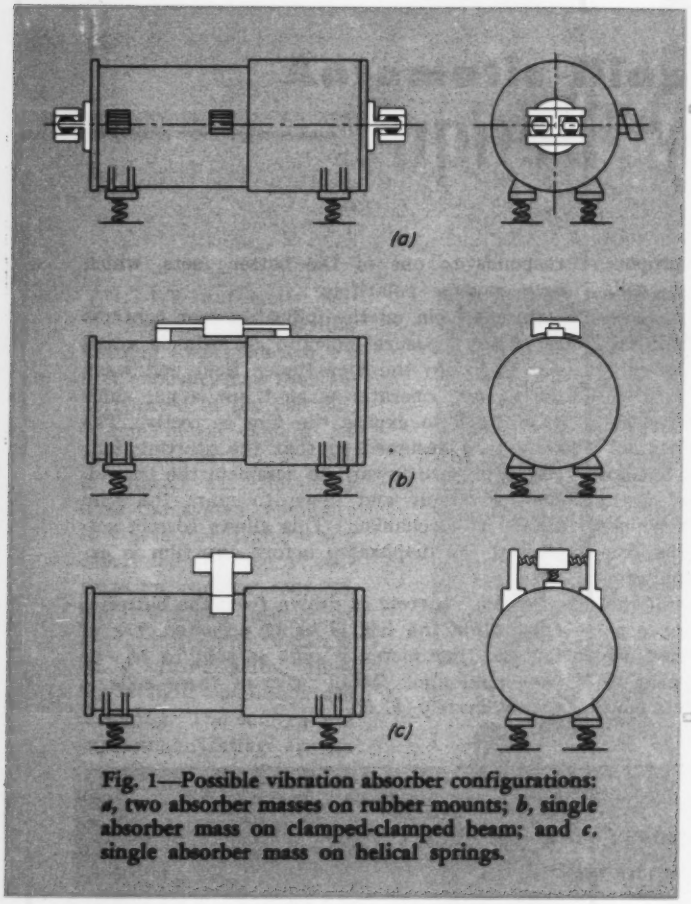


Fig. 1—Possible vibration absorber configurations: *a*, two absorber masses on rubber mounts; *b*, single absorber mass on clamped-clamped beam; and *c*, single absorber mass on helical springs.

A DYNAMIC vibration absorber, Fig. 1, is a spring-mass system added to a machine installed on isolation mounts to decrease vibration transmission from the machine to its supporting structure. This decrease in vibration transmission is accomplished by transferring the impressed force or torque to the absorber rather than to the structure.

When properly applied, the absorber becomes an impressive means of reducing vibrations, even below the level reached with the careful selection and installation of vibration mounts. The absorber is particularly adaptable to constant-speed machinery. However, as will be seen later, it is usually not to be used for variable-speed devices. For the former application, the absorber can be designed so that its natural frequency can be precisely tuned to the operating frequency of the vibration-generating equipment. Considerable isolation is thus obtained.

Vibration reduction is usually indicated by transmissibility—the ratio of transmitted force (or torque) to impressed force (or torque). Transmissibility is the widely accepted criterion for vibration isolation. When it is zero, an isolation frequency is established; when it reaches a very high value, a resonant frequency is found. Thus, it is desirable to know the transmissibilities, isolation frequencies, and resonant frequencies.

Vibration Caused by Rotational Unbalance

A rotating machine, Fig. 2, has an unbalanced rotor creating an impressed centrifugal force F_c on the system. Its mounts form a base under and symmetrically about the center of gravity. Thus, this system includes the majority of rotary machinery installations. For simplicity, damping in the mounts has been neglected.

With a base-mounted system it is known that the vertical mode of vibration can be considered independently of the rocking mode.[1] The rocking mode consists of a horizontal motion of the machine coupled with a rotational motion about the center of gravity.

Vertical Vibration: Transmissibility in the vertical direction can be derived by applying Newton's

[1] References are tabulated at end of article.

methods for designing

Vibration Absorbers

. . . a technique for "absorbing" vibration of constant - speed machines with an auxiliary spring-mass system

By Harry Himelblau Jr.
Senior Research Engineer
North American Aviation Inc.
Los Angeles, Calif.

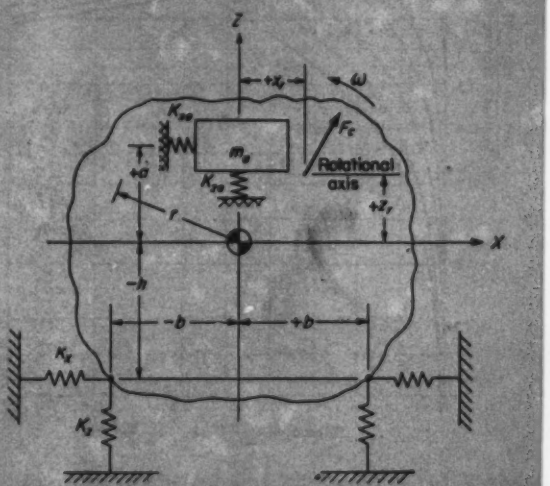


Fig. 2—Generalized concept of a rotating machine on vibration mounts, with a dynamic vibration absorber added to reduce vibration created by a centrifugal force.

equation (force = mass × acceleration) to both the resiliently mounted machine and its absorber, and performing some mathematical manipulations. Following an analysis similar to that in Reference 2, the vertical transmissibility is

$$T_z = \frac{F_{zo}}{F_c} = \left[\left(\frac{\omega_{za}}{\omega_z}\right)^2 - \left(\frac{\omega}{\omega_z}\right)^2\right] \Big/ \left\{\left(\frac{\omega}{\omega_z}\right)^4 - \left[1 + \left(1 + \frac{m_a}{m}\right)\left(\frac{\omega_{za}}{\omega_z}\right)^2\right]\left[\frac{\omega}{\omega_r}\right]^2 + \left(\frac{\omega_{za}}{\omega_z}\right)^2\right\} \quad (1)$$

The vertical isolation frequency ω_{zi} is found where $T_z = 0$. By equating the numerator of Equation 1 to zero,

$$\omega_{zi} = \omega_{za} \quad (2)$$

Thus, when the absorber vertical natural frequency ω_{za} is tuned to the operating frequency or speed ω of the centrifugal force, no vibration is transmitted from the machine to its supporting structure.

Unwanted vertical resonant frequencies ω_{r_h} and ω_{r_l} are determined by setting the denominator of Equation 1 to zero:

$$\frac{\omega_{r(h,l)}}{\omega_z} = \left\{ \frac{1}{2}\left[1 + \left(1 + \frac{m_a}{m} \right)\left(\frac{\omega_{za}}{\omega_z} \right)^2 \right] \pm \sqrt{\frac{1}{4}\left[1 + \left(1 + \frac{m_a}{m} \right)\left(\frac{\omega_{za}}{\omega_z} \right)^2 \right]^2 - \left(\frac{\omega_{za}}{\omega_z} \right)^2} \right\}^{1/2} \quad (3)$$

These frequencies should never coincide with the operating frequency ω because destructive vibration magnification would result. Fig. 3 presents a graphical solution to Equation 3, with the lower and higher resonant frequencies each being compared with the absorber vertical natural frequency and being represented by a family of curves. Several important characteristics can be seen from Fig. 3:

1. The lower resonant frequency ω_{rl} is always less than the absorber vertical natural frequency ω_{za}, while the higher resonant frequency ω_{rh} is always greater.
2. The greater the absorber mass m_a compared to the machine mass m, the wider the spread between each unwanted resonant frequency and the desirable isolation frequency ($\omega_{zi} = \omega_{za}$).
3. For small absorber masses ($m_a/m < 0.2$), the closer the vertical natural frequency ω_{za} of the absorber is to the vertical natural frequency ω_z of the resiliently mounted machine, the wider the spread betwen ω_r and ω_{zi}, as in point 2 just mentioned.

Nomenclature

a = Vertical distance from the absorber to the center of gravity, in.
b = Horizontal distance from the mounts to the center of gravity, in.
F_c = Impressed centrifugal force, lb
F_{xo}, F_{zo} = Horizontally and vertically transmitted vibrational forces, respectively, lb
h = Vertical distance from the mounts to the center of gravity, in.
K_x, K_z = Total horizontal and vertical dynamic spring rates, respectively, of the machine mounts, lb per in.
K_{xa}, K_{za} = Total horizontal and vertical dynamic spring rates, respectively, of the absorber mounts, lb per in.
M_t = Impressed oscillating torque, lb-in.
M_{to} = Oscillating torque transmitted vertically through mounts, lb-in.
m, m_a = Masses of the machine and absorber, respectively, lb-sec^2 per in.
r = Radius of gyration of the machine about its center of gravity, in.
T = Transmissibility
x_r, z_r = Horizontal and vertical distances, respectively, from the machine shaft to the center of gravity, in.
ω, ρ = Frequency of the impressed centrifugal force and impressed oscillating torque, respectively, radians per sec
ω_i, ρ_i = Isolation frequencies at which one or more transmissibilities are zero, radians per sec
ω_r, ρ_r = Resonant frequencies at which one or more transmissibilities are theoretically infinite, radians per sec. Subscripts h and l denote high and low frequencies, respectively.
ω_{xa} = Horizontal natural frequency of the absorber, radians per sec
$= (K_{xa}/m_a)^{1/2}$
ω_z = Vertical natural frequency of the machine on its mounts, radians per sec
$= (K_z/m)^{1/2}$
ω_{za} = Vertical natural frequency of the absorber, radians per sec.
$= (K_{za}/m_a)^{1/2}$

Note: Where complex subscript notations have been used, the following definitions apply: a = of the absorber; h = high; i = isolation frequency; l = low; o = transmitted through mounts; m = moment; r = resonant frequency; t = caused by oscillating torque; x = horizontal direction; z = vertical direction.

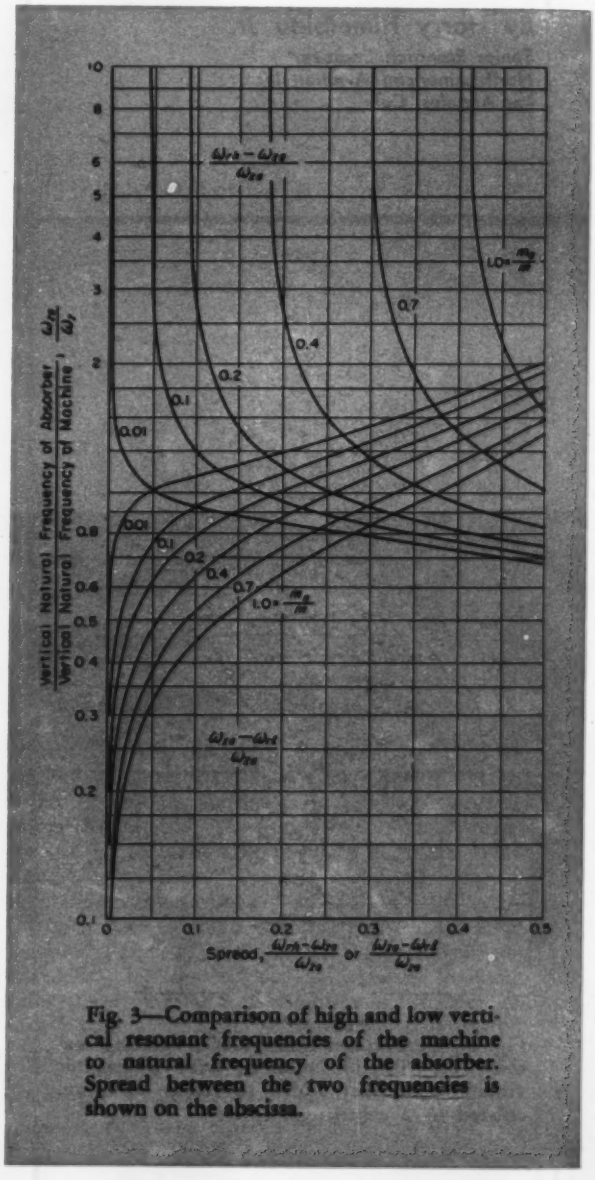


Fig. 3—Comparison of high and low vertical resonant frequencies of the machine to natural frequency of the absorber. Spread between the two frequencies is shown on the abscissa.

The information from paragraphs 2 and 3 can be utilized for installations where the machine's operating speed ω is nearly constant and equal to $\omega_{xi} = \omega_{xa}$, but deviates slightly because of changing electrical or mechanical loads, etc. Fig. 3 shows the deviation necessary to bring the machine from isolation to unwanted resonance, as a function of m_a/m and ω_{xa}/ω_x, so that an absorber mass or machine natural frequency can be selected to eliminate this possibility.

Before considering other aspects of vertical vibrations, it would be desirable to review the basic properties of rocking mode oscillations.

Rocking Vibration: Horizontal and moment transmissibilities[3] are obtained by considering vibrations in the rocking mode. The horizontal transmissibility due to horizontal vibration forces on the mounts is

$$T_x = \frac{F_{xo}}{F_e} = \left(A_x^2 - 2\frac{h}{r} A_x A_a \cos\left(\psi - \phi\right) + \left(\frac{h}{r}\right)^2 A_a^2 \right)^{1/2} \tag{4}$$

while the moment transmissibility because of rocking forces vertically on the mounts is

$$T_m = \frac{M_{ao}}{F_a \sqrt{(h - z_r)^2 + x_r^2}} = \frac{(b/r)^2 A_a}{\frac{K_x}{K_z}\sqrt{\left(\frac{h}{r} - \frac{z_r}{r}\right)^2 + \left(\frac{x_r}{r}\right)^2}} \tag{5}$$

In Equations 4 and 5, values for variables A_x, A_a, ψ and ϕ must be determined. These values are

$$A_x = \frac{\sqrt{\left(B^4 - IB^2 + J + C\frac{z_r}{r}\right)^2 + \left(C\frac{x_r}{r}\right)^2}}{B^6 - EB^4 + GB^2 - H} \tag{6.0}$$

$$A_a = \frac{\sqrt{\left(PB^2 - Q + D\frac{z_r}{r}\right)^2 + \left(D\frac{x_r}{r}\right)^2}}{B^6 - EB^4 + GB^2 - H} \tag{6.1}$$

$$\tan\psi = \frac{-\left(B^4 - IB^2 + J + C\frac{z_r}{r}\right)}{C\frac{x_r}{r}} \tag{6.2}$$

$$\tan\phi = \frac{PB^2 - Q + D\frac{z_r}{r}}{-D\frac{x_r}{r}} \tag{6.3}$$

Involved in the solution of Equations 6.0 through 6.3 are three variables

$$B = \omega/\omega_x \tag{6.4}$$

$$C = P\left(\frac{\omega}{\omega_x}\right)^2 - Q \tag{6.5}$$

$$D = \left(\frac{\omega}{\omega_x}\right)^4 - L\left(\frac{\omega}{\omega_x}\right)^2 + N \tag{6.6}$$

Also necessary for solution of Equations 6.0 through 6.6 are values for several constants. These values, which are constant for a particular configuration and choice of machine mounts are

$$E = \frac{K_x}{K_z} + \frac{K_x}{K_z}\left(\frac{h}{r}\right)^2 + \left(\frac{b}{r}\right)^2 + \left[1 + \frac{m_a}{m} + \frac{m_a}{m}\left(\frac{a}{r}\right)^2\right]\left[\frac{\omega_{xa}}{\omega_x}\right]^2 \tag{7.0}$$

$$G = \frac{K_x}{K_z}\left(\frac{b}{r}\right)^2 + \left[\frac{K_x}{K_z} + \frac{K_x}{K_z}\left(\frac{h}{r}\right)^2\left(1 + \frac{m_a}{m}\right) + \left(\frac{b}{r}\right)^2\left(1 + \frac{m_a}{m}\right) + \frac{K_x}{K_z}\frac{m_a}{m}\frac{a}{r}\left(\frac{a}{r} - 2\frac{h}{r}\right)\right]\left[\frac{\omega_{xa}}{\omega_x}\right]^2 \tag{7.1}$$

$$H = \frac{K_x}{K_z}\left(\frac{b}{r}\right)^2\left(\frac{\omega_{xa}}{\omega_x}\right)^2 \tag{7.2}$$

$$I = \frac{K_x}{K_z}\left(\frac{h}{r}\right)^2 + \left(\frac{b}{r}\right)^2 + \left[1 + \frac{m_a}{m}\left(\frac{a}{r}\right)^2\right]\left[\frac{\omega_{xa}}{\omega_x}\right]^2 \tag{7.3}$$

$$J = \left[\frac{K_x}{K_z}\left(\frac{h}{r}\right)^2 + \left(\frac{b}{r}\right)^2\right]\left[\frac{\omega_{xa}}{\omega_x}\right]^2 \tag{7.4}$$

$$L = \frac{K_x}{K_z} + \left(1 + \frac{m_a}{m}\right)\left(\frac{\omega_{xa}}{\omega_x}\right)^2 \tag{7.5}$$

$$N = \frac{K_x}{K_z}\left(\frac{\omega_{xa}}{\omega_x}\right)^2 \tag{7.6}$$

$$P = \frac{K_x}{K_z}\frac{h}{r} + \frac{m_a}{m}\frac{a}{r}\left(\frac{\omega_{xa}}{\omega_x}\right)^2 \tag{7.7}$$

$$Q = \frac{K_x}{K_z}\frac{h}{r}\left(\frac{\omega_{xa}}{\omega_x}\right)^2 \tag{7.8}$$

Although the resulting group of equations looks confusing, the solution is really straightforward and should not cause undue concern. Equations 7.0 through 7.8 are constants for the particular machine, mounts and absorber. Equations 6.4 through 6.6 represent recurring terms used in Equations 6.0 through 6.3. And once these are solved, the solution of Equations 4 and 5 is not complicated. Values of the phase angles, ψ and ϕ, can be found from their tangents in Equations 6.2 and 6.3 by using Table 1.

In addition to finding the transmissibilities, it would be advantageous to pin-point the rocking mode isolation and resonant frequencies. The rocking isolation frequencies are too complex to obtain, except in the very common case when the rotational

Table 1—Quadrants for Phase Angles (Equations 6.2 and 6.3)

If numerator is . . .	And denominator is . . .	Phase angle, ψ or ϕ, is . . . (degrees)
+	+	0 to 90
+	−	90 to 180
−	−	180 to 270
−	+	270 to 360

axis passes through the center of gravity ($x_r = z_r = 0$). In this case the higher and lower horizontal isolation frequencies ω_{ih} and ω_{il} are established by setting Equation 4 to zero:

$$\frac{\omega_{ih,il}}{\omega_z} = \left[\frac{1}{2} R \pm \sqrt{\frac{1}{4} R^2 - \left(\frac{b}{r}\right)^2 \left(\frac{\omega_{xa}}{\omega_z}\right)^2} \right]^{1/2} \quad (8)$$

where

$$R = \left(\frac{b}{r}\right)^2 + \left(\frac{\omega_{xa}}{\omega_z}\right)^2 + \frac{m_a}{m} \frac{a}{r} \left(\frac{a}{r} - \frac{h}{r}\right) \left(\frac{\omega_{xa}}{\omega_z}\right)^2$$

Example: Motor-Generator Set With Vibration Absorber

A motor-generator set, Fig. 1-1, has a slightly unbalanced shaft. It weighs 3750 lb, and its operating speed is 1800 rpm (essentially constant). Its shaft passes through the center of gravity, ($x_r = z_r = 0$). Base dimensions and radius of gyration are: $h = -14.75$ in.; $b = 12$ in.; and $r = 9.1$ in.

To isolate the set from the supporting foundation, four resilient mounts are installed, each having a horizontal and vertical dynamic spring rate of 20,300 and 17,500 lb per in. Thus

$$K_x = 4 \times 20{,}300 = 81{,}200 \text{ lb per in.}$$
$$K_z = 4 \times 17{,}500 = 70{,}000 \text{ lb per in.}$$

Based on these facts, the machine mass and vertical natural frequency are

$$m = \frac{3750}{386} = 9.72 \text{ lb-sec}^2/\text{in.}$$

$$\omega_z = \sqrt{\frac{70{,}000}{9.72}} = 84.8 \text{ radians/sec}$$

Expressing the operating speed in the same units of vertical natural frequency:

$$\omega = \frac{2\pi}{60} 1800 = 188.5 \text{ radians/sec}$$

Thus, the following ratios are determined:

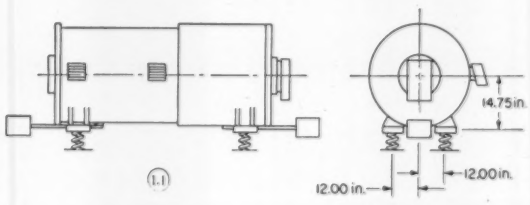
$$\frac{h}{r} = \frac{-14.75}{9.1} = -1.62$$

$$\frac{b}{r} = \frac{12}{9.1} = 1.32$$

$$\frac{K_x}{K_z} = \frac{81{,}200}{70{,}000} = 1.16$$

$$\frac{\omega}{\omega_z} = \frac{188.5}{84.8} = 2.22$$

An absorber is selected which can be precisely tuned to the machine's operating speed ($\omega_{za} = \omega_{xa} = \omega$), has a mass one-tenth of that of the machine ($m_a/m = 0.10$), and is attached to the



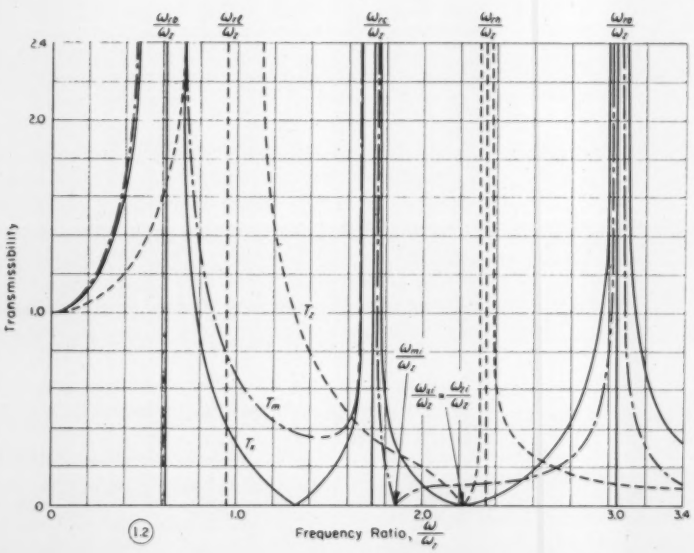


Fig. 1-1 — Above — Motor-generator set equipped with cantilever-spring dynamic vibration absorber. These springs were chosen because absorber masses could be located under the machine for better space utilization, and because they were economical and easy to install.

Fig. 1-2—Left—Transmissibility curves for motor-generator set with a dynamic vibration absorber.

Likewise, the moment isolation frequency ω_{mi} is found by setting Equation 5 (actually the numerator of Equation 6.1) to zero:

$$\frac{\omega_{mi}}{\omega_z} = \left\{ \frac{\frac{K_x}{K_z}\frac{h}{r}\left(\frac{\omega_{xa}}{\omega_z}\right)^2}{\frac{K_x}{K_z}\frac{h}{r} + \frac{m_a}{m}\frac{a}{r}\left(\frac{\omega_{xa}}{\omega_z}\right)^2} \right\}^{1/2} \quad (9)$$

Resonant frequencies ω_{ra}, ω_{rb}, and ω_{rc}, can be determined for any value of x_r and z_r, however, by equating the denominators of Equations 6.0 and 6.1 to zero.

$$\left(\frac{\omega}{\omega_z}\right)^6 - E\left(\frac{\omega}{\omega_z}\right)^4 + G\left(\frac{\omega}{\omega_z}\right)^2 - H = 0 \quad (10.0)$$

By setting

$$p = \frac{E^2}{9} - \frac{G}{3} \quad (10.1)$$

and

$$q = \frac{E^3}{27} - \frac{EG}{6} + \frac{H}{2} \quad (10.2)$$

three types of solutions are possible.

machine between its mounts ($a = -14.75$ in.). Thus,

$$\frac{a}{r} = \frac{-14.75}{9.1} = -1.62$$

$$\frac{m_a}{m} = \frac{375}{3750} = 0.10$$

$$\frac{\omega_{za}}{\omega_z} = \frac{\omega_{xa}}{\omega_z} = \frac{188.5}{84.8} = 2.22$$

Substituting these ratios in Equation 1, and in Equations 7.0 through 7.8 for use in Equations 6.0 through 6.6 and then in Equations 4 and 5, the three transmissibilities are established: $T_z = 0$; $T_x = 0$; and $T_m = 0.11$. Horizontal and vertical vibrations are essentially eliminated, and moment transmissibility found at a very low level.

Instead of considering only one frequency ($\omega = 188.5$ radians per sec), the characteristics of the system can be understood much better by letting the frequency vary over a range. Plotting the three transmissibilities, T_x, T_y and T_z, versus ω/ω_z gives Fig. 1-2. This graph vividly demonstrates the locations of resonant frequencies in the rocking mode (0.62, 1.73, 3.05) and that all transmissibilities are small only at the last isolation frequency ($\omega/\omega_z = 2.22$).

Fig. 1-2 also shows the difficulty of properly applying the absorber to variable-speed devices or constant-speed machines without close speed control. If the motor-generator set were run at the somewhat higher speed of 1900 rpm ($\omega/\omega_z = 2.35$), unwanted vertical resonance would result.

However, for constant-speed machines with slight deviations, the frequency range between operating speed and vertical resonance could be widened by using a larger absorber weight. If the absorber mass were doubled ($m_a/m = 0.20$), resonance would occur at 2000 rather than 1900 rpm. Fig. 3 can be utilized for determining this speed.

Without the dynamic vibration absorber, transmissibilities are found to be substantially higher, as shown in Fig. 1-3 (Ref. 3). At the same frequency ($\omega/\omega_z = 2.22$), the transmissibilities are: $T_z = 0.26$; $T_x = 1.12$; and $T_m = 0.63$.

Thus, the advantage of the tuned absorber for constant-speed machines is aptly demonstrated. However, the comparison of Figs. 1-2 and 1-3 shows that the machine with the absorber must pass through three resonant points when starting and coming up to speed, while the machine without the absorber must pass through only two. In certain installations this disadvantage may be enough to offset the superior isolation properties of the absorber.

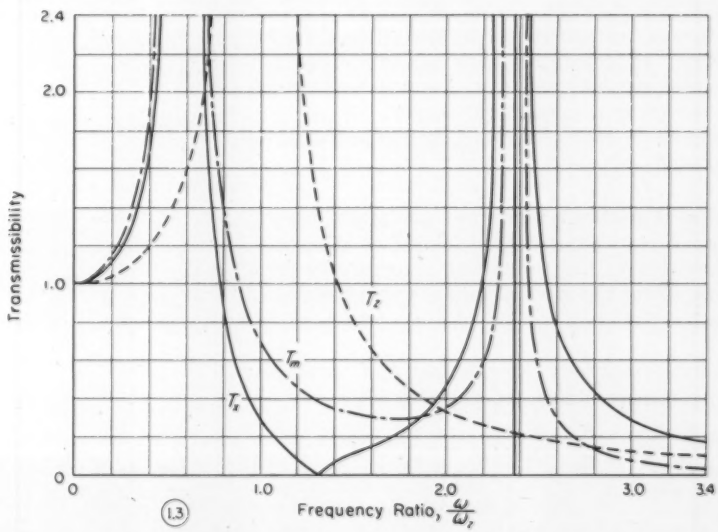


Fig. 1-3 — Transmissibility curves without the vibration absorber.

If $q^2 - p^3 > 0$, only one resonant frequency is found:

$$\frac{\omega_{ra}}{\omega_z} = \left[\left(q + \sqrt{q^2 - p^3} \right)^{1/3} + \left(q - \sqrt{q^2 - p^3} \right)^{1/3} + \frac{A}{3} \right]^{1/2} \quad (11)$$

If $q^2 - p^3 = 0$, two resonances are determined:

$$\frac{\omega_{ra}}{\omega_z} = \sqrt{2\,q^{1/3} + \frac{A}{3}} \quad (12.0)$$

$$\frac{\omega_{rb}}{\omega_z} = \sqrt{-\,q^{1/3} + \frac{A}{3}} \quad (12.1)$$

If $q^2 - p^3 < 0$, all three resonances are present:

$$\frac{\omega_{ra}}{\omega_z} = \sqrt{2\,p^{1/2} \cos \frac{u}{3} + \frac{A}{3}} \quad (13.0)$$

$$\frac{\omega_{rb}}{\omega_z} = \sqrt{2\,p^{1/2} \cos \left(\frac{u}{3} + \frac{2\pi}{3} \right) + \frac{A}{3}} \quad (13.1)$$

$$\frac{\omega_{rc}}{\omega_z} = \sqrt{2\,p^{1/2} \cos \left(\frac{u}{3} + \frac{4\pi}{3} \right) + \frac{A}{3}} \quad (13.2)$$

where

$$\cos u = \frac{q}{p^{3/2}} \qquad [0 < u < \pi] \quad (13.3)$$

Vertical Plus Rocking Vibration: Summarizing the analysis, transmissibilities can be found from Equations 1, 4 and 5. Isolation frequencies are determined from Equations 8 and 9 for $x_r = z_r = 0$ and Equation 2. Resonant frequencies are found from Equations 11, 12 or 13 and, in addition, Equation 3. The Example shows how these can be applied to a practical vibration problem.

Vibration Caused by Oscillating Driving Torque

Vibration transmission from an impressed oscillating torque, such as caused by the magnetic field of a motor or generator[4], can be determined by using methods similar to those for predicting vibrations from a centrifugal force. By use of the diagram in Fig. 4, the torque transmissibility can be found.

Vertical Vibration: Since no oscillatory forces are applied vertically to the machine, no vibration is transmitted to the supporting structure in this direction. Thus the vertical torque transmissibility T_{tz} is zero.

Rocking Vibration: Horizontal and moment torque transmissibilities are given by

$$T_{tx} = \frac{F_{xo}}{\left(\frac{M_t}{h}\right)} = \frac{K_x}{K_z} \frac{h}{r} \left\{ P \left(\frac{\rho}{\omega_z} \right)^2 - Q + \left[\left(\frac{\rho}{\omega_z} \right)^4 - L \left(\frac{\rho}{\omega_z} \right)^2 + N \right] \frac{h}{r} \right\} \div \left[\left(\frac{\rho}{\omega_z} \right)^6 - E \left(\frac{\rho}{\omega_z} \right)^4 + G \left(\frac{\rho}{\omega_z} \right)^2 - H \right] \quad (14)$$

and

$$T_{tm} = \frac{M_{to}}{M_t} = -\left(\frac{b}{r} \right)^2 \left[\left(\frac{\rho}{\omega_z} \right)^4 - L \left(\frac{\rho}{\omega_z} \right)^2 + N \right] \Big/ \left[\left(\frac{\rho}{\omega_z} \right)^6 - E \left(\frac{\rho}{\omega_z} \right)^4 + G \left(\frac{\rho}{\omega_z} \right)^2 - H \right] \quad (15)$$

Values to be substituted in the above equations appear in Equations 7.0 through 7.8. From Equation 14, the two horizontal isolation frequencies are:

$$\rho_{xil} = 0 \quad (16)$$

$$\frac{\rho_{xih}}{\omega_z} = \left[\frac{1 - \frac{m_a}{m} \left(\frac{a}{r} - \frac{h}{r} \right)}{\frac{h}{r}} \right]^{1/2} \frac{\omega_{xa}}{\omega_z} \quad (17)$$

while from Equation 15 the moment isolation frequencies are

$$\frac{\rho_{mih,\,mil}}{\omega_z} = \frac{1}{2} \left[\frac{K_x}{K_z} + \left(1 + \frac{m_a}{m} \right) \left(\frac{\omega_{xa}}{\omega_z} \right)^2 \right] \pm \left\{ \frac{1}{4} \left[\frac{K_x}{K_z} + \left(1 + \frac{m_a}{m} \right) \left(\frac{\omega_{xa}}{\omega_z} \right)^2 \right]^2 - \frac{K_x}{K_z} \left(\frac{\omega_{xa}}{\omega_z} \right)^2 \right\}^{1/2} \quad (18)$$

One, two, or three resonant frequencies may be present. They can be found by substituting ρ_r for ω_r in Equations 11 through 13.3.

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2. J. P. Den Hartog—*Mechanical Vibrations*, Third Edition, McGraw-Hill Book Co. Inc., 1947, Pages 112-119.
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4. Reference 2, Pages 92-93.

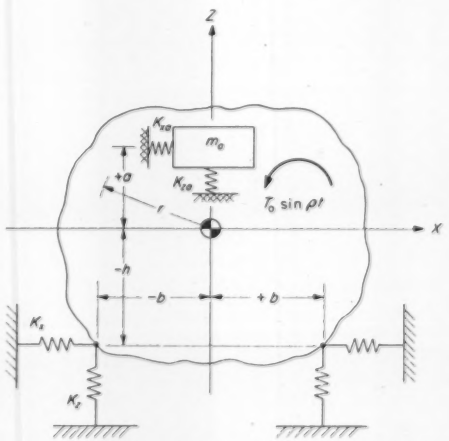

Fig. 4—Generalization of a rotating machine on base mounts with a vibration absorber added to take care of oscillating torque.

Round Tubes in Bending

How to select optimum diameter for minimum weight

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TUBE design has been a trial-and-error process and has no standard of comparision for minimum weight in existing design procedures. Presented in this article are typical design curves which will help solve the following problems:

1. Selecting diameter and wall thickness for minimum weight, given a bending moment and material.
2. Selecting wall thickness for minimum weight, or wall thickness corresponding to any preselected margin of safety, given diameter and bending moment.
3. Finding tube bending stiffness corresponding to any bending strength.

Design and selection of tubular members are affected, of course, by other factors—availability of raw stock (bar stock, forgings, extrusions, etc.) in the required size, space restrictions, machinability limits, and manufacturing limitations.

Fundamental Relationships: The elementary stress formula for the bending of a round tube is

$$\sigma_b = \frac{MR}{I} \tag{1}$$

Moment of inertia can be expressed as

$$I = \frac{\pi}{64}\left[D^4 - (D-2t)^4\right]$$

$$= \frac{\pi}{8}(n^3 - 3n^2 + 4n - 2)\,t^4 \tag{2}$$

When n is large,

$$I = \frac{\pi}{8} D^3 t = \frac{AD^2}{8} \tag{3}$$

Combining Equations 1 and 2,

$$\sigma_b = \frac{4MD}{\pi(n^3 - 3n^2 + 4n - 2)\,t^4} \tag{4}$$

When n is large, Equation 4 becomes

$$\sigma_b = \frac{4M}{\pi D^2 t} = \frac{4M}{AD} \tag{5}$$

For a zero margin of safety,

$$\sigma_b = \sigma_{ba} \tag{6}$$

Combining Equations 4 and 6,

$$\frac{M}{D^3} = \phi\,\sigma_{ba} \tag{7}$$

where

$$\phi = \frac{\pi}{4}\,\frac{n^3 - 3n^2 + 4n - 2}{n^4}$$

Now,

$$A = \frac{\pi}{4}\left[D^2 - (D-2t)^2\right]$$

$$= \pi(n-1)t^2 \tag{8}$$

Nomenclature

A = Sectional area, sq in.
D = Outside diameter, in.
E = Young's modulus, psi
I = Moment of inertia, in.^{4}
M = Bending moment, in-lb
$n = D/t$
R = Outside radius, in.
R_h = Stress ratio
S = Stiffness, lb-in.^{2}
t = Wall thickness, in.
ρ = Material density, lb per cu in.
σ_b = Applied bending stress, psi
σ_{ba} = Bending modulus of rupture, psi
σ_u = Ultimate tensile stress, psi

Combining Equations 4 and 8,

$$\sigma_b = \frac{4\,MD}{A\,(n^2 - 2n + 2)\,t^2} = \sigma_{bu} \qquad (9)$$

Solving Equation 9 for A gives

$$A = \frac{4n}{n^2 - 2n + 2} \cdot \frac{M}{t\sigma_{bu}} \qquad (10)$$

Dividing Equation 10 by $M^{2/3}$,

$$\frac{A}{M^{2/3}} = \beta \frac{M^{1/3}}{D\,\sigma_{bu}} \qquad (11)$$

where

$$\beta = \frac{4n^2}{n^2 - 2n + 2}$$

From Equation 7,

$$\frac{M^{1/3}}{D} = \sqrt[3]{\phi\,\sigma_{bu}} \qquad (12)$$

Combining Equations 11 and 12,

$$\frac{A}{M^{2/3}} = \beta \sqrt[3]{\phi} \frac{1}{(\sigma_{bu})^{2/3}} \qquad (13)$$

Since curves for bending modulus of rupture σ_{bu} are always plotted against n, and since ϕ and β are functions of n, the right-hand sides of Equations 12 and 13 are immediately determined from n. Hence, $M^{1/3}$ may be plotted against n, Fig. 1, and similarly $A/M^{2/3}$ against n, Fig. 2.

Next, tube stiffness can be expressed as

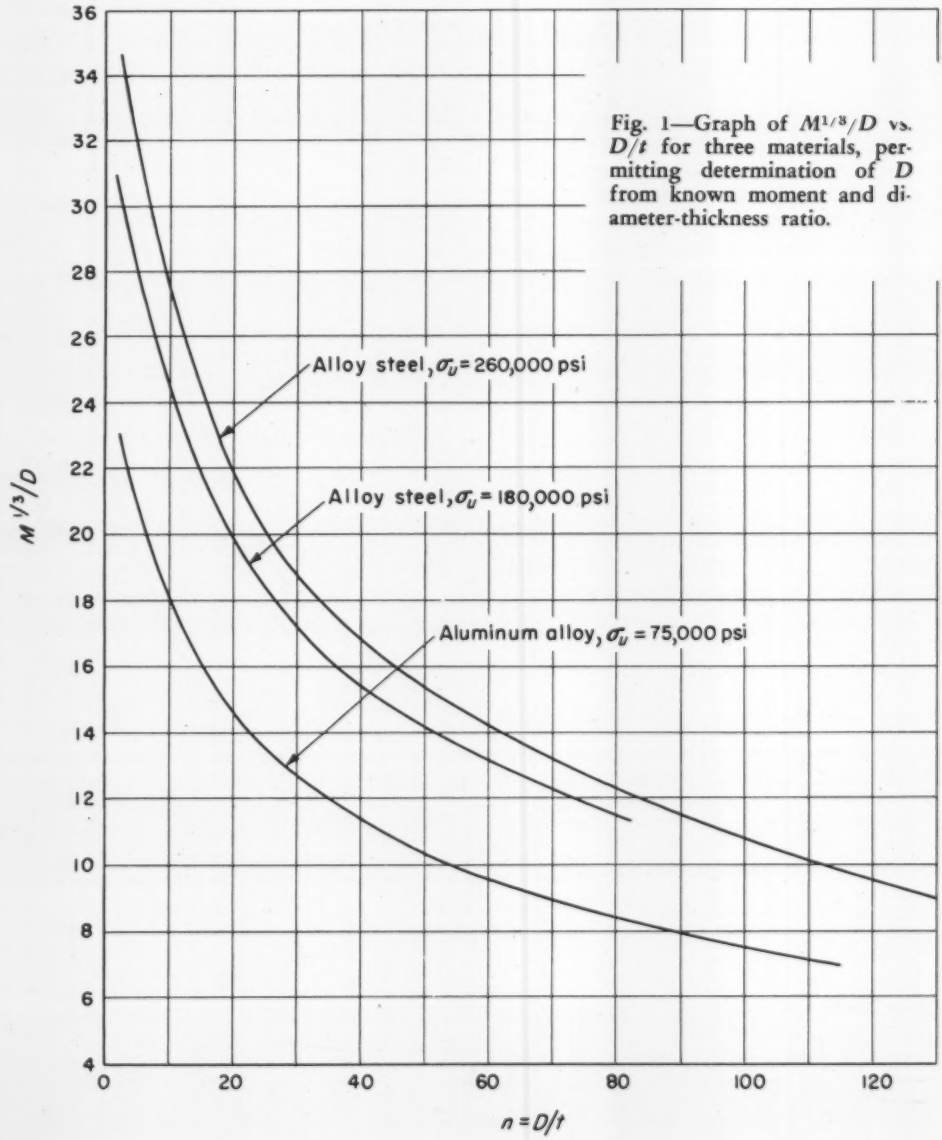

Fig. 1—Graph of $M^{1/3}/D$ vs. D/t for three materials, permitting determination of D from known moment and diameter-thickness ratio.

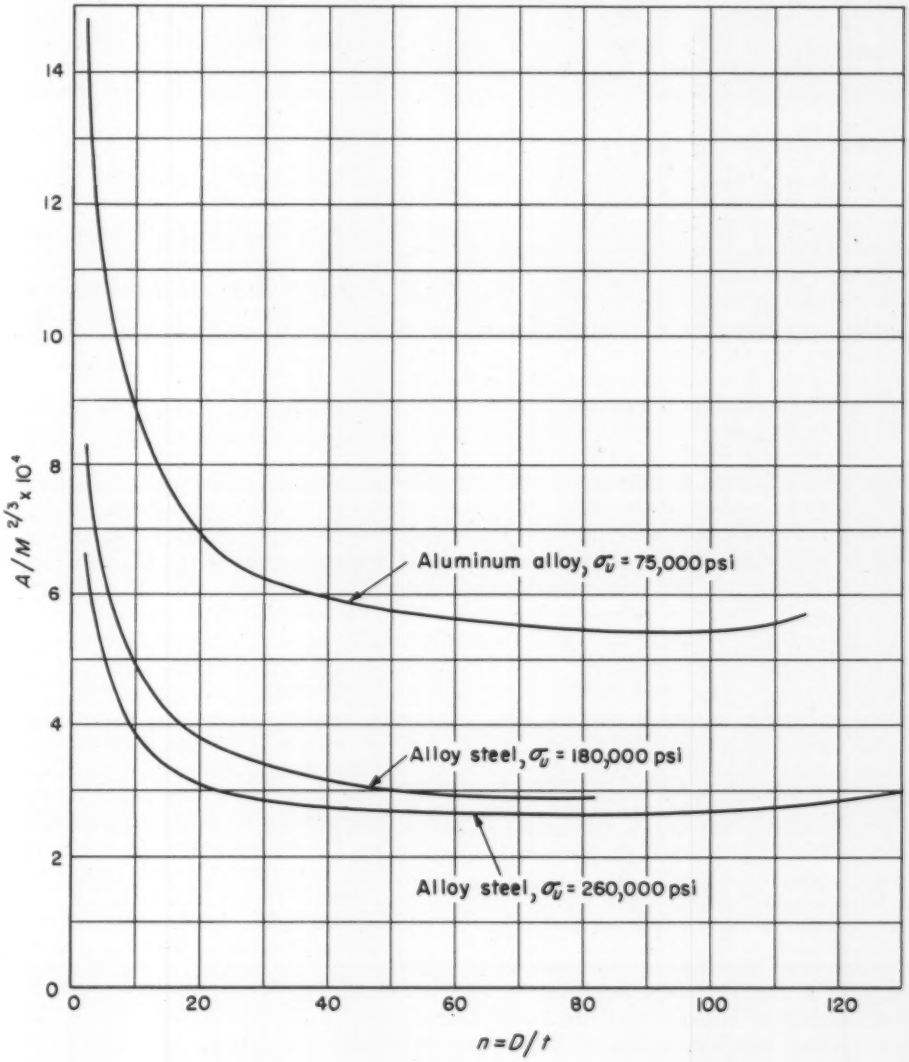

Fig. 2 — Above — Graph of $A/M^{2/3}$ vs. D/t for three materials, permitting determination of sectional area from known moment and diameter-thickness ratio.

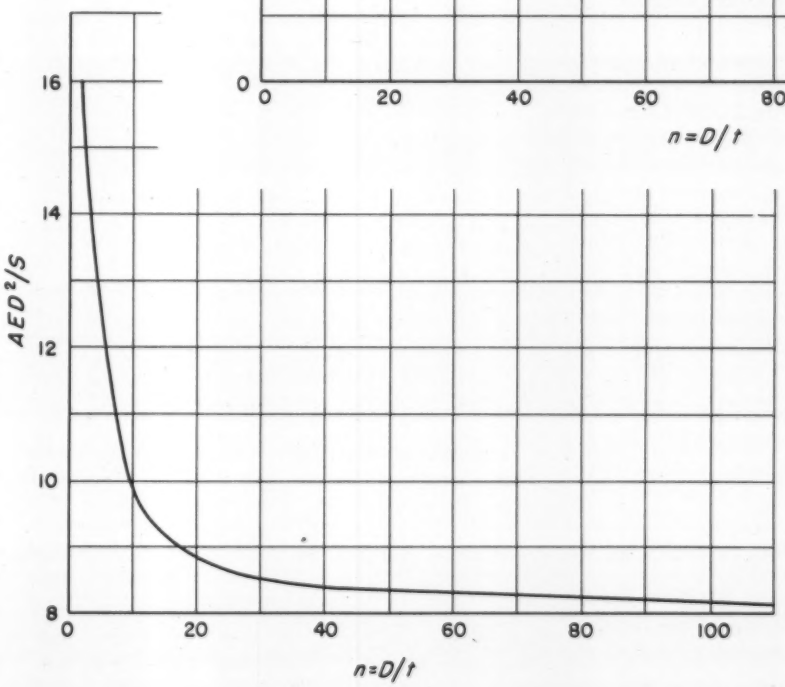

Fig. 3—Left—Graph of AED^2/S vs. D/t for finding stiffness.

$$S = EI = E\frac{\pi}{8}(n^3 - 3n^2 + 4n - 2)\,t^4 \qquad (14)$$

When n is large,

$$S = \frac{AED^2}{8}$$

Combining Equations 8 and 14,

$$\frac{AED^2}{s} = \frac{8n^2}{n^2 - 2n + 2} = 2\beta \qquad (15)$$

Thus, AED^2/S may be plotted against n, Fig. 3.

From these equations, the curves are drawn for alloy steels of two strength levels, 180,000 and 260,000 ultimate tensile strength. Although the curves are not extended beyond $n = D/t = 130$, it is not implied that this is a theoretical or practical limit. The maximum useable ratio will, however, depend on the method used in manufacturing the tube—extruding and machining, drawing, wrapping and riveting, forging and machining, etc. For tubes in bending, it has been found that four ranges of D/t exist, each corresponding to a different mode of failure:

$0 \leq D/t \leq 10$	Failure in plastic bending and no local instability.
$10 \leq D/t \leq 20$	Failure in plastic bending with local instability exhibiting a single transverse fold.
$20 \leq D/t \leq 2000$	Failure by local instability exhibiting one or more inward diamond - shaped buckles. Failure is in the plastic range at the lower values, and is apparently locally plastic at the higher values.
$D/t > 2000$	Failure by elastic instability in the form of inward diamond-shaped buckles.

The curves indicate that for some value of D/t, between 90 and 100, a minimum weight is attained. For unstiffened circular shells in 24S-T aluminum alloy (now designated 2024-T) Shanley* shows that $D/t = 90$, with a corresponding modulus of rupture of 50,000 psi, provides minimum weight. When the tube must be machined, it has been found that $D/t = 60$ is usually a practical limit. The curves indicate that only a small weight reduction can be achieved by increasing D/t from 50 to 60. However, with certain recently developed techniques, such as "chemical milling," higher D/t values can be obtained.

Procedure: Use of Figs. 1-3 in the solution of typical problems involves the following steps:

1. From given values of M and n, determine $M^{1/3}/D$ from Fig. 1 for zero margin of safety. Solve for D.
2. Determine $A/M^{2/3}$ from Fig. 2. Solve for A.
3. Solve for $t = [A/\pi(n-1)]^{1/2}$.
4. Determine AED^2/S from Fig. 3. Solve for S.
5. If it is desirable to maintain a stress ratio in bending, $R_b = \sigma_b/\sigma_{ba}$, less than unity because of additional loadings, D and A should be selected from the curves for zero margin of safety and then modified as follows:

$$D_{req} = \frac{D_{zero\ margin}}{\sqrt[3]{R_b}}$$

$$A_{req} = \frac{A_{zero\ margin}}{(R_b)^{2/3}}$$

It is interesting to note from Equation 13 that, for a given value of n and a given material, the sectional area is proportional to $M^{2/3}$.

Curves similar to Figs. 1 and 2 can be developed for other materials from basic data in conjunction with the foregoing mathematical developments.

Example 1: Find tube size and determine relative weights for $D/t = 30$, $M = 10^6$, and zero margin of safety.

Alloy steel, $\sigma_u = 180{,}000$ psi: From Fig. 1, $M^{1/3}/D = 17.3$ in. Hence, diameter $D = 5.78$ in. From Fig. 2, $A/M^{2/3} = 3.37 \times 10^{-4}$. Hence area $A = 3.37$ sq in. and weight $= 3.37\ (0.284) = 0.955$ lb per in. From Fig. 3, $AED^2/S = 8.5$. Therefore, stiffness $S = 3.37\ (29 \times 10^6)\ (5.78)^2/8.5 = 383 \times 10^6$ lb-in.^{2} From Equation 8, wall thickness $t = [A/\pi(n-1)]^{1/2} = [3.37/\pi(29)]^{1/2} = 0.192$-in.

Alloy steel, $\sigma_u = 260{,}000$ psi: By the same process, $D = 5.29$ in., $A = 2.84$ sq in., weight $= 0.805$ lb per in., $S = 272 \times 10^6$ lb-in.^{2}, $t = 0.177$-in.

Aluminum alloy, $\sigma_u = 75{,}000$ psi: Similarly, $D = 7.85$ in., $A = 6.25$ sq in., weight $= 0.625$-lb per in., $S = 453 \times 10^6$ lb-in.^{2}, $t = 0.262$-in.

Weight reduction realized with steel, $\sigma_u = 260{,}000$ psi, in lieu of steel, $\sigma_u = 180{,}000$ psi, is $100(3.37 - 2.84)/3.37 = 15.7$ per cent. Weight reduction realized with aluminum, $\sigma_u = 75{,}000$ psi, in lieu of steel, $\sigma_u = 260{,}000$ psi, is $100(0.85 - 0.625)/0.805 = 22.4$ per cent.

Example 2: Find tube sizes in steel for $n = 50$, $M = 10^6$, and zero margin of safety.

Alloy steel, $\sigma_u = 180{,}000$ psi: From Fig. 1, $M^{1/3}/D = 14.3$ in. Hence, $D = 7.0$. From Fig. 2, $A/M^{2/3} = 3.03 \times 10^{-4}$. Hence, $A = 3.03$ sq in. From Equation 8, $t = 0.141$-in.

Alloy steel, $\sigma_u = 260{,}000$ psi: Similarly, $D = 6.54$ in., $A = 2.67$ sq in., and $t = 0.132$-in.

In this case, steel, $\sigma_u = 260{,}000$, in lieu of steel, $\sigma_u = 180{,}000$, leads to a weight reduction of $100(3.03 - 2.67)/3.03 = 12$ per cent.

Example 3: Find tube wall thicknesses in steel and aluminum alloys and relative weights for $M = 10^6$ and $D = 6$. From Figs. 1 and 2,

	n	t (in.)	$A/M^{2/3}$	Weight per in. (lb.)
Aluminum, $\sigma_u = 75{,}000$	13	0.375	8.0×10^{-4}	0.80
Steel, $\sigma_u = 180{,}000$	32	0.187	3.33×10^{-4}	0.947
Steel, $\sigma_u = 260{,}000$	40	0.15	2.7×10^{-4}	0.767

*F. R. Shanley—*Weight-Strength Analysis of Aircraft Structures*, McGraw-Hill Book Co., New York, 1952, Page 43.

How to control closely co-ordinated motor operations with

DESIGN ABSTRACTS

Adjustable-Frequency AC Drives

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THE squirrel-cage motor is widely used in spite of the fact that it is essentially a constant-speed machine. If the supply frequency is adjustable, however, these motors can be made to operate with most of the flexibility of the dc machine. In fact, an adjustable-frequency system has many advantages over a dc drive. Group drives, for example, can be made to operate together closely over a wide speed range without special adjustments. Starting, acceleration, and switching of single motors in a group drive can be done easily with the ac system, but require special treatment with dc motors.

The added cost of an adjustable-frequency supply is partly offset by the savings afforded by the simplified squirrel-cage motor construction. But to be an important factor, many motors must be involved. For this reason, adjustable-frequency drives have been used most often for such applications as steel mill run-out tables, or spinning machines for man-made fibers, where hundreds of small motors may be required for a single drive.

Further justification for the separate power supply is the elimination of brushes, slip rings and commutators, all of which contribute to maintenance costs. This is a very real limitation for certain high-speed applications. High-speed spinning devices, for example, must operate from 8000 to 10,000 rpm—speeds that would destroy brushes and commutators in a very short time.

In locations subject to adverse atmospheric conditions, such as acid or water mists, hydrogen sulfide, or occasional steam vapors, the ac adjustable-frequency drive shows even greater advantage because there are no brushes, commutators, or slip rings on the ac motors mounted at the machine.

Another timely example is the "canned" motor-pump used widely for nuclear-power installations, where no connection is permitted between stator and rotor. In this case, adjustable-frequency control of even a single motor is the only practical scheme.

The basic elements of an adjustable-frequency drive are shown in Fig. 1. This system is used for a merchant and rod-mill run-out table in a steel mill, Fig. 2. All of the table motors are energized from the adjustable-frequency ac generator, which in turn is driven by a dc motor energized from the plant bus. The dc motor is started at full field by armature-resistance control, and its speed is controlled by field weakening. The motor-operated rheostat for the motor field has a rheostat plate for the ac generator field also, which provides for overexcitation at the low-frequency end of the range to provide more torque. The ac table motors are started at low frequency across the line. At the same time the generator field is overexcited momentarily to provide the additional excitation needed to take care of starting conditions.

Speed changing after the motors are running is accomplished by

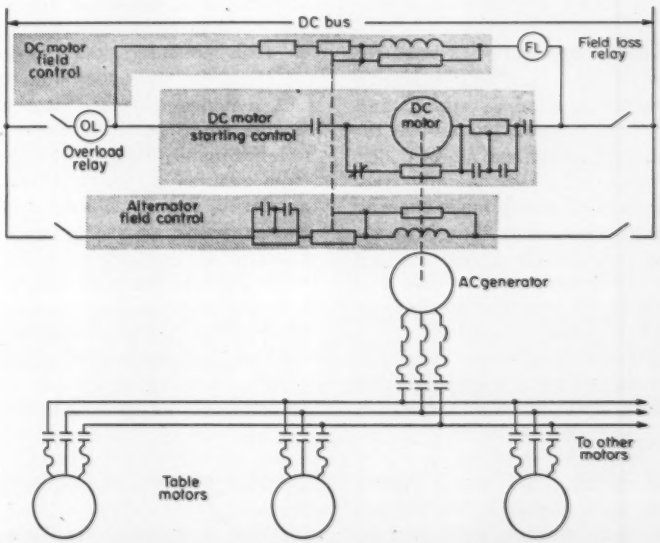


Fig. 1—Schematic of a typical adjustable-frequency drive, as applied to a run-out table for a rod and merchant mill.

manipulation of a master switch that controls the motor-operated rheostat. When stopping the drive, the motors are brought to low speed by frequency control and then coast to rest after the ac line contactor opens. Other drive systems having more precise methods of control are commonly used, but these represent refinements of the basic system shown here.

Drive Motors: When an adjustable-frequency power supply of the proper characteristics is provided, squirrel-cage induction and synchronous motors will operate over a wide speed range with essentially constant torque capability. This permits the simple construction of the squirrel-cage or similar synchronous motor to be combined with the flexibility of an adjustable-speed drive. The maintenance-free operation of squirrel-cage induction motors and reluctance-type or permanent-magnet synchronous motors have permitted machinery designers to lay out machines for greatest operator convenience and efficiency. Regular maintenance requirements are reduced to a minimum since there are no brushes, slip rings, commutators or contacts. By the use of switches or plug connectors, individual sections may be removed from production for repairs or replacement without costly unscheduled shutdown of the rest of the machine.

Synchronous motors are required where all sections must run at exactly the same speed, and where precise speed control is required. Synchronous motors lock into step with the supply frequency and at steady loads there is no speed error. The slip of the induction motor introduces a speed error that is dependent on the load and will exist even though the control of frequency is perfect.

Adjustable-frequency drives using induction motors are desirable when various driven-machine sections need not be driven at exactly identical or precisely controlled speeds. The inherent slip of induction motors provides excellent load division between sections of a machine tied together by the machine or the product.

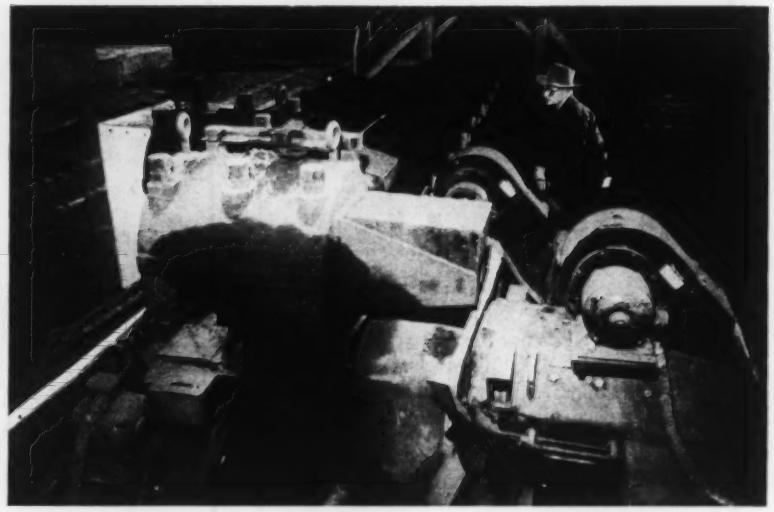


Fig. 2—Rod-mill run-out table with individual motor driving each roll. An adjustable-frequency power supply maintains uniform roll speed.

Adjustable - Frequency Supply: In all but very special applications, the adjustable-frequency supply consists of either a synchronous generator, or an induction frequency changer, driven by an adjustable-speed drive, Fig. 3. The drive may be a dc constant or adjustable-voltage drive, mechanical or hydraulic adjustable - speed drive or an ac adjustable-speed drive. Other types of drives may also be used, the selection depending upon speed range, horsepower requirements, torque characteristics of the load, regulation and control requirements, and other such considerations as space, maintenance, efficiency and costs.

A synchronous generator is desirable when parts of the adjustable-frequency system must start from rest as a complete unit and accelerate simultaneously. Also, a synchronous generator is most economical and practical for obtaining low frequencies in the range of 40 cycles and lower. Excitation for a synchronous generator comes from a dc supply. The generator field is excited at a relatively fixed value, and therefore the voltage generated is approximately proportional to the speed; frequency is exactly proportional to speed.

Since a wound-rotor induction frequency changer has an output frequency at standstill equal to primary frequency, it is less suitable than a synchronous generator for starting drives by adjustable-frequency control. The induction frequency changer is generally best applied to drives operating above constant line frequency where the motors can be started at the operating frequency. The induction frequency changer is excited from the available ac power supply; output voltage and frequency result from the added effects of transformer action and rotation of the rotor. With fixed ac excitation on the primary of the wound-rotor machine, the output voltage and frequency vary with speed of rotation, or slip.

Characteristics of Adjustable-Frequency Equipment: All of the ac machines in an adjustable-frequency system are capable of operating at essentially constant flux, over a given frequency range. Voltage generated in the armature winding of an ac motor or generator is proportional to flux and frequency. Therefore, if the iron is worked economically at a fixed value of flux, the generated voltage will be proportional to the frequency. The ratio of generated volts per cycle is the same at high or low frequency for constant flux. Terminal voltage of a motor is higher, and that of a generator is lower, by the amount of the inter-

nal impedance drop of the machine. Except for limitations due to reduced ventilation at low speed, the machines are capable of carrying the same load current over a wide frequency range. With fixed flux and constant load current, constant torque capabilities are obtained from the machine.

It is a characteristic of induction and synchronous motors that line and primary-winding impedance drops tend to limit torque at low frequencies. If the voltage is raised slightly at low frequency to overcome the *IR* drop in the primary winding and leads, torque is increased. This voltage boost is readily obtained on the synchronous generators used for low-frequency applications. At frequencies above 60 cycles, no boost is required.

The volts per cycle usually need not be raised more than 15 per cent for minimum frequencies above 15 cycles. And for low-inertia loads, little or no boost is required. The minimum boost necessary to insure satisfactory operation should be used, since a raise in volts per cycle will adversely affect generator size and performance.

Although no standards exist for adjustable-frequency drive equipment, the inherent constant-torque and constant volts-per-cycle characteristics of motors and generators offer a sound basis for standardization. While the maximum and minimum frequencies vary widely with the application requirements, motors can all be rated on the basis of one of the standard motor voltages at 60 cycles—preferably 220/440 volts at 60 cycles, but possibly based on 55 or 110 volts at 60 cycles if voltage must be limited. Voltage limits may be imposed by safety considerations or by the voltage rating of distribution apparatus.

Standardization of volts per cycle for generators is basically the same as that for motors—1, 2, 4 or 8 volts per cycle. This allows the use of basic 60-cycle generator designs, which in the case of large generators with a small number of turns per coil is a real advantage, since these designs are somewhat inflexible. The generator voltage rating should be slightly higher than that of the motors to offset line drop. Standardization of kva per cycle is not proposed because the requirements of various types and sizes of machines are so different.

A 15 per cent boost in volts per cycle requires no major change in generator electrical design. Field heating is the limitation in operating over a speed range because of the reduced ventilation at low speeds and greater losses due to volts-per-cycle boost at low speed. Except on some rotating-armature generators, forced ventilation is required for cooling at speeds below about 600 rpm.

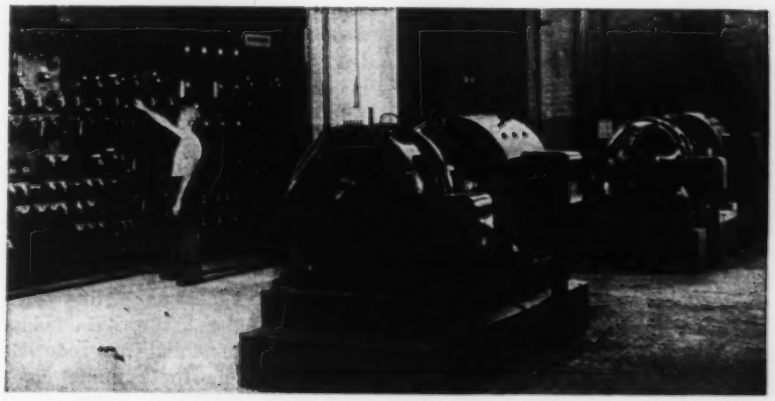
Similarly, since both induction and synchronous motors have constant-torque characteristics, the horsepower capability will vary with the frequency. Selection of motor horsepower rating on a basis of the equivalent capacity at 60 cycles is desirable. For example, if a section of a machine requires 4.3 hp at 3850 rpm, the equivalent 4-pole, 60-cycle motor capable of the same torque output would be rated 2 hp at 60 cycles and 1750 rpm. The frequency at top speed would be 130 cycles, and the voltage would be 477 volts, corresponding to 220 volts at 60 cycles.

This rating method permits use of standard 60-cycle induction and synchronous motors and reduces the special design work required for an adjustable-frequency drive.

Starting Methods: The motor-starting method for an adjustable-frequency drive system depends on the particular requirements of the application, and the limitations of the power supply. The available starting methods commonly used are (1) adjustable-frequency starting, (2) across-the-line starting at any frequency, or (3) reduced-voltage starting at any frequency. Since reluctance synchronous motors have greater starting torque and current than squirrel-cage induction motors of the same horsepower rating, the size of the ac generator for line-starting a reluctance motor must be greater than for induction motors of the same horsepower. However, since the reluctance-motor starting and accelerating torque is high at rated voltage, reduced-voltage starting can be used even when full-load or higher torque is required to break away from static friction of the load.

A typical situation illustrating two methods of starting is a machine having several tandem components, each driven by synchronous motors powered from the same source, Fig. 4. When starting such a machine, all sections should be started together and brought up to an initial speed suitable for threading or other operations preliminary to steady operation. As the generator speed increases, the voltage and frequency also increase until the synchronous motors develop enough induction-motor torque to break away static friction of the load. The motors then gradually accelerate, lagging behind the generator speed by an amount sufficient to develop the

Fig. 3—Typical adjustable-frequency supply consisting of a three-phase generator driven by an adjustable-speed dc motor.



necessary torque, until a high enough voltage and frequency are attained to cause the motors to pull into step. This must occur below threading speed to cause the machine sections to run at the exact relative speeds suitable for the prelimiary operation. Earlier speed differences during acceleration to preliminary operating or threading speed are not a disadvantage at that stage.

Adjustable - frequency starting of the entire machine is the most economical. No increase in generator kva or kw rating is necessary as compared to running requirements, and no increase in generator-drive size is required to take care of this starting method. Across-the-line starting, even if it could be used, would require a bigger generator and drive.

After all motors are running in synchronism at threading speed and all preliminary operations have been completed, speed is gradually and smoothly raised to production speed. The ac generator field is overexcited during acceleration to provide increased voltage and pull-out torque.

The second method of starting is illustrated by a situation that may prevail in certain kinds of tandem-driven equipment. For example, given a machine consisting of two sections, it may be desirable to keep the first section operating at production speed while cleaning or adjusting the second section. The second section can be shut down with the multiple synchronous-motor drive. After the interruption, this part of the machine can be restarted at production speed and frequency. Motors of 20 per cent of total horsepower are started across the line, with the generator field overexcited to minimize voltage drop. Starting inrush current is greater than full load on the generator and causes an appreciable impact speed drop on the system, which is not objectionable in this application.

Recent drive systems have included single-step primary reactor starters to limit current, and particularly the watts inrush upon starting the motor. A reactor has the desirable characteristic that its reactance varies with frequency

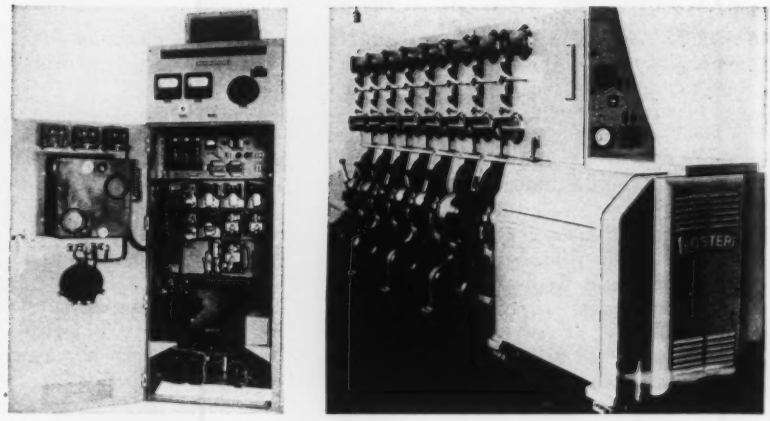


Fig. 4—Two basic elements of a nylon spinning-machine drive consisting of control cabinet, left, containing an electronic regulator for precision frequency control, and the eight-position winder, right, which has each feedwheel individually motored and regulated by the adjustable-frequency supply.

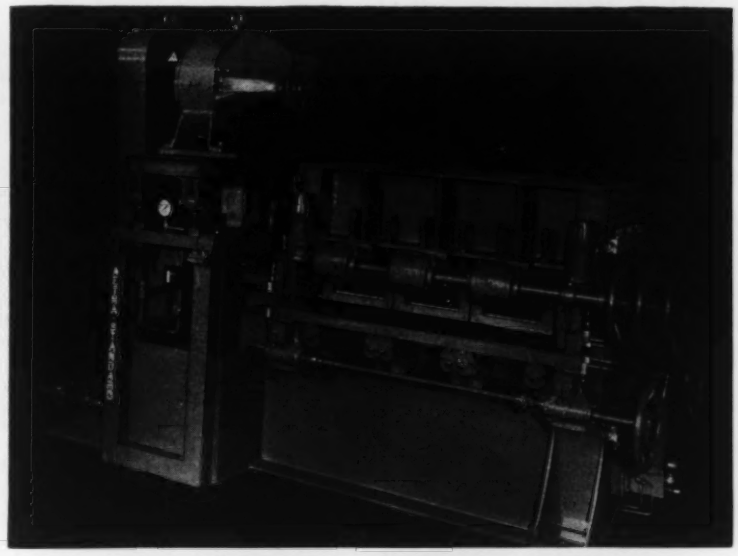
and that its power factor is low. The impedance drop is approximately in phase with motor voltage under locked conditions at any frequency. A reactor selected to limit starting current to a given value at the high-frequency end of the speed range inherently allows approximately the same inrush current to flow at lower frequencies.

A resistance starter, on the other hand, provides a voltage drop in proportion to the current, and results in greater limiting action at low frequency. Furthermore, the addition of resistance to the primary circuit of a motor for reduced-voltage starting may actually increase the watts drawn from the line and thereby make the impact speed drop worse rather than better.

Another method of starting employs a motor powered through by a continuously adjustable autotransformer. The motor is connected to the autotransformer at zero volts and the motor voltage gradually increased until the torque is sufficient to start the load. The voltage continues to increase until the motor is transferred to the line at 100 per cent voltage. In special cases the voltage may be raised above line voltage for pulling high-inertia loads into synchronism and then reduced to line voltage for running continuously. The motor-driven autotransformer is used principally on drives where the impact speed drop must be limited to an extremely small value.

A fixed-tap autotransformer can also be used for motor starting at any operating frequency on an adjustable-frequency system. It has the advantage of lower kva demand than a reactor, but has the disadvantage of requiring more elaborate switching. A reactor starter inherently provides closed-circuit transition. When synchronous motors are used, regardless of the starting method, full voltage is required when pulling into synchronism. Reluctance-synchronous motors exhibit the characteristic that pull-in torque varies as a power between the square and cube of applied voltage. A 10 per cent reduction in voltage at the motor can, therefore, cause a 25 per cent reduction in pull-in torque. During pull-in, the motor may draw three times full-load current so that any impedance drop in the generator, motor, and motor leads will be accentuated. At low frequencies, the line drop and motor-winding *IR* drop is a greater percentage of applied voltage than at high frequency. The volts per cycle at the low-frequency end of the speed range is usually raised to overcome the *IR* drop and provide full synchronizing

BEARING TIPS by McGill



138 GUIDEROL® BEARINGS BACK UP WORK ROLLS IN AETNA STANDARD LEVELER

High load capacity vital to back-up roll support

For processing 16 to 30 gauge steel sheets and coils, this Roller Leveler built by Aetna Standard Engineering Company requires dependable components to deliver a consistent maximum output at speeds up to 400 feet a minute.

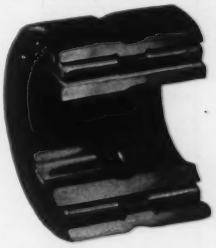
McGill GUIDEROL GR-16 bearings were selected for this machine and several larger versions use GR-24 and GR-36 bearings. They can carry the heavy irregular loads associated with flattening and leveling steel sheets and strips. Requiring less radial space, Guiderol bearings provide maximum roll neck diameters and offer greater strength at the necks of larger back-up rollers.

On the machine shown above, there is a total of 36 back-up rollers in 3 upper banks and 33 in 3 lower banks to resist the heavy pressure of the 48 inch working rolls. With a GUIDEROL bearing at each end of the 1¾" back-up rolls, a total of 138 bearings is required for the Leveler. These bearings have proved especially suited to supporting heavy loads longer in small radial space with reduced maintenance and production down time — important in steel mill operations.

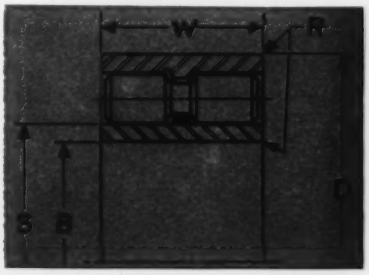
American Hoist Uses CT Series In Crane Blocks

Crane Blocks built by American Hoist and Derrick to withstand the greater strains and rough usage of lifts up to 500 tons rely on the greater capacity of GUIDEROL CT Series bearings in the sheaves. Interchangeable with retainer type cylindrical roller bearings, the CT Series full type roller construction has added capacity of over 38%. In sheaves these bearings offer greater angular stability with full race width rollers. Center guiding without retainer keeps these rollers aligned and prevents binding under eccentric loads.

Center-Guided Rollers Eliminate Load Wasting Cages



Guiderol Bearings inherently possess exceptionally high radial load capacity due to their full complement of small diameter rollers. Grooved rollers and a center guide rail keep rollers aligned as insurance against skewing and binding that is possible with ordinary needle bearings. Sizes interchange with needle and cylindrical roller bearings.



CT Series Adds Guided Roller Advantages to Cylindrical Roller and Ball Bearing Sizes

CT Series Guiderol Bearings provide the load carrying advantages of center guided rollers in cylindrical roller and ball bearing sizes. They are interchangeable in both single and double row dimensions. Inner rings are separable and may be eliminated to reduce radial space.

140 Pages of Bearing Facts

Write for your copy of Catalog No. 52, a revised 140-page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Full Type Roller Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

torque. Such loads as pumps having lower torque requirements at low speed require little or no boost in volts per cycle at the motor.

Braking Methods: Since squirrel-cage induction and reluctance synchronous motors are most commonly used on adjustable-frequency drives, dynamic braking for quick stops can be obtained by applying dc excitation to the motor windings from a low-voltage rectifier or other source of direct current. For example, in the tandem-driven machine referred to previously, the second section is stopped quickly from any production speed in an emergency by dc dynamic braking. Very high braking torques can be obtained by sufficient dc excitation, and there is no tendency to reverse or coast. The dc excitation is removed by a timing relay after the motor has had time to stop.

If the entire adjustable-frequency drive must be braked to a stop, it is sometimes convenient to use regenerative braking, which is achieved by reducing the supply-voltage frequency rapidly. This is done by braking the supply generator drive.

From "Adjustable - Frequency AC Drives" in Westinghouse Engineer, *July* 1956.

High stress capacity creates wide application possibilities for

Polyurethane Rubber

By G. H. Gates and W. M. Larson

Research Div.
Goodyear Tire & Rubber Co.
Akron, Ohio

IN THE rubber and plastics fields, polyurethane is classed as a rubber. In comparing some of the physical properties of polyurethane with natural rubber and GR-S, polyurethane has an elongation comparable to many pure gum natural-rubber compounds together with a much higher stress capacity. Fig. 1 shows a comparison of stress-strain tests on a pure gum natural-rubber stock, a polyurethane gum stock and two black-reinforced stocks, one natural rubber and one GR-S.

Fig. 2 shows a comparison of hardness of polyurethane to other polymers. Processible polyurethane is comparable in hardness to other rubbers, whereas cast polyurethane, without loading, is much harder than the other polymers. In comparison to other rubbers, the outstanding property of polyurethane is abrasion resistance. A comparison of polyurethane to an abrasion - resistant natural rubber-tread stock is shown in Fig. 3. In addition to tire treads, this property is being investigated in such fields as abrasion-resistant hose. In one particular case, hose with a polyurethane cover is presently on test in mines and quarries where it is desirable to improve hose life by reducing the cover wear. Hose cores of polyurethane are being tested for transportation of sand and other abrasive materials.

Industrial Tires: In the factory where abrasion and/or metal adhesion is a problem with solid industrial tires, polyurethane rubber is giving excellent performance. Rubber-to-iron adhesion systems are being used in which peel strength approaches 100 lb per in. Here the metal hub is degreased, shot-blasted and two coats of isocyanate cement applied before application of the polyurethane rubber. Service life of 3 months (and still running) is reported on one of the latest test wheels. The wheels

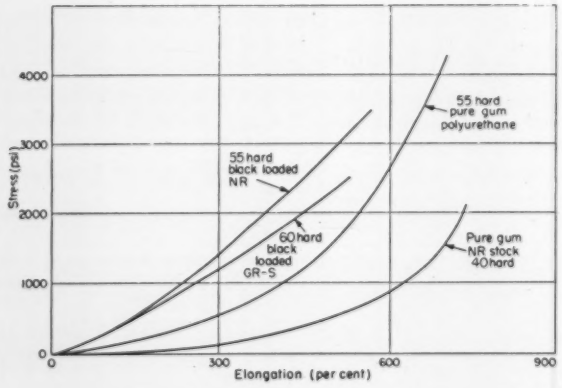


Fig. 1—Comparison of stress-strain characteristics of polyurethane, natural rubber (NR) and government rubber-styrene (GR-S), with Shore A hardnesses indicated.

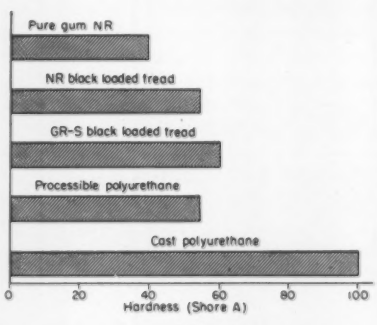


Fig. 2—Hardnesses of polyurethane, natural rubber and GR-S.

HOWELL MOTOR BRIEFS

Quick facts for those who apply and specify electric motors

Installation Facility: Bonus Value in Motors

When you specify electric motors, do you consider their "installation facility" — the ease and freedom from difficulties with which motors can be put in use? It's a bonus value that can cut costs in your final assembly or in your customer's plant (wherever the motors are installed).

Steel Feet, Steel Frames Take Punishment Best

Howell Series 100 motors, with the new, smaller dimensions, have heavy steel feet welded to die-formed steel frames. No cracking of cast iron frame or mounting foot here. When a workman drops a motor down too hard, or applies that last excess twist of a wrench to a mounting bolt, Howell's tough steel frame and mounting feet can take it.

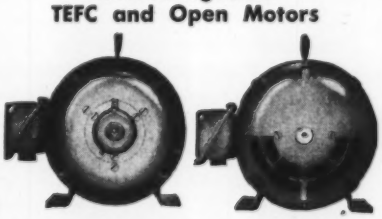
Howell's steel frame construction does much to avoid the delay and expense of motor replacements at the time of final machine assembly.

Position-Identified Leads Insure Correct Wiring

Leads on Howell Series 100 Motors are designated on the nameplate by their positions at the entrance to the conduit box. Each position is identified by an easily read, raised numeral on the neoprene lead block that seals the entrance from the motor. There are no tags, strips or clips to become lost or illegible.

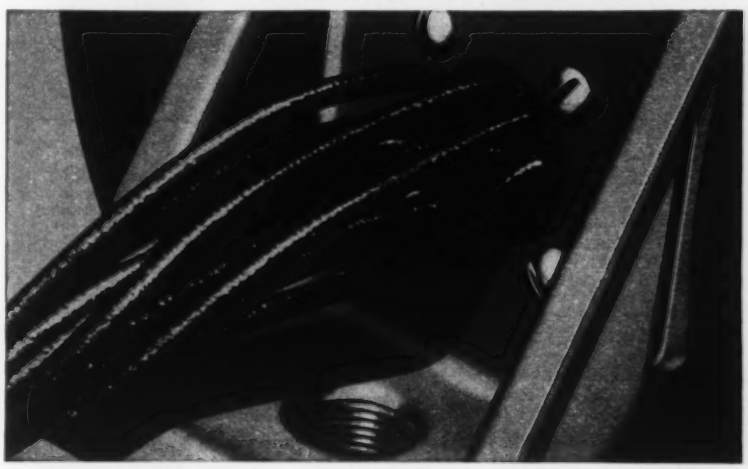
Howell lead identification not only speeds the original installation, it's permanent for easy re-installation, at any time during these motors' long working life.

Interchangeable TEFC and Open Motors



Totally enclosed fan cooled and open-type motors in Howell's Series 100 have the same diameter and mounting dimensions. This simplifies space allocation in your machine designs and allows quick, easy substitution of one type for the other in the field.

Resilient steel feet of Howell motors take any kind of stress during installation. Pads are ground flat after stator assembly to insure perfect mounting alignment.



Howell leads are permanently identified where they enter box from motor. Note time-saving, integral threaded nipple and easy four-way rotation of box to take conduit from any direction.

Get the details on all the bonus features of Howell Series 100 Motors — Write for Bulletin N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

Circle 571 on page 19

are the load-bearing wheels of electric trucks used throughout the factory for transporting materials and equipment. Ordinarily these wheels last a few weeks to a few months depending on the severity of usage. In this particular instance several trucks had been modified to increase their load-carrying capacity.

Originally these trucks were built to carry a single skid of stock. A second lift was added above the original platform. Two skids of stock could then be carried in place of one. This doubled the load from 1600 to 3200 lb, but no provision was made for increasing the size or number of load-bearing wheels. A polyurethane solid-tire wheel was installed and has been in use continuously for the past 3 months with a minimum of chipping and cutting. Control tires are replaced every few weeks. Where the regular solid tires have a hardness of 81 Shore A, this particular cast polyurethane tire has a Shore A of 100.

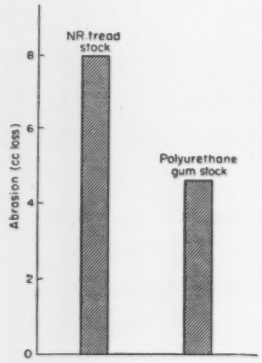


Fig. 3—Comparative ring-abrasion losses of polyurethane and natural rubber during a 20-min abrasion period.

High-Pressure-Pump Valve Inserts: Another recent development is the use of polyurethane valve inserts in high-presure mud pumps used in oil-well drilling operations. These pumps force drilling mud or slurry into the drilling system. The valve inserts of these pumps are subjected to high operating pressures and excessive abrasion during the drilling operation.

Over a period of time, many types of materials have been tried as inserts and discarded. The most satisfactory commercial material proved to be an oil and heat-resistant Neoprene compound. The first experimental polyurethane inserts of Vulcollan, which have just been removed, gave four times the service life of the regular material. This was a hard material—100 Shore A. Further tests are continuing using a specially compounded polyurethane but evaluation on the latest inserts has not been completed in the field tests.

Motor Mounts: What appears to be a relatively simple problem of anchoring machinery actually can become quite complex. Generally a motor mount is used to reduce vibration. Too hard a stock has no vibration-damping qualities — the motor might as well be fastened directly to the supporting medium. Conversely, too soft a stock can have good damping qualities but will deform like a piece of chewing gum. A good mount will dampen the vibrations and harmonics over a wide range without deforming beyond the restricted limits of the equipment.

Data have been obtained which indicate that polyurethane should be a good motor-mounting material. Table 1 is a compilation of data comparing polyurethane to the natural rubber GR-S motor-mount stock used in Cadillac automobiles. The higher heat rise and hysteresis loss in polyurethane is believed to be indicative of the ability of this material to absorb vibration energy. The higher dynamic modulus of the polyurethane is interpreted to mean that less stock will be necessary to achieve equivalent spring constant as compared to the control.

Sponges and Foam: Table 2 has been prepared to compare some useful properties of latex, and open and closed-cell polyurethane foams. Outstanding properties of the polyurethane foams include low density and high compressive strength as compared to latex foam. In comparison, the resilience of the polyurethane expanded foams looks promising with respect to vibration damping.

From a paper entitled "Polyurethane Rubber as a Material of Construction" presented at the ASME Semi-Annual Meeting in Cleveland, June, 1956.

Table 1—Motor-Mount Test Data

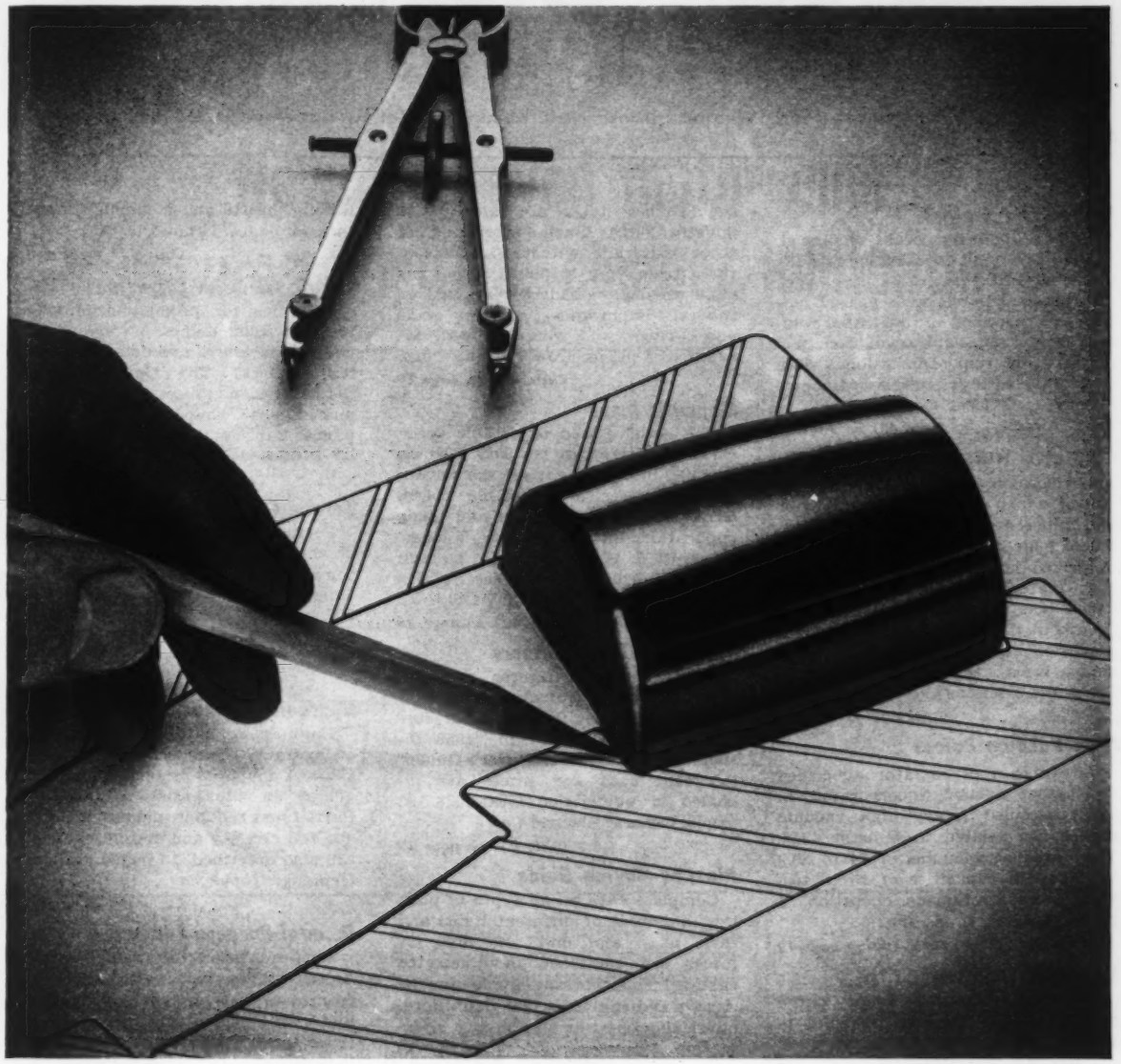
	Natural Rubber, GR-S	Polyurethane (no loading)	Polyurethane (black loaded)
Hardness, Shore A	53	60	70
Compression set*			
At 77 F	18.37	14.03	15.81
At 158 F	25% max	30.77	35.97
Dynamic modulus, kg/cm	50.0	91.1	103.3
Internal friction, kilopoises	16.0	59.6	32.2
Resilience, per cent	46.8	41.6	45.5
Hysteresis loss, instron			
Energy absorbed, in.-lb			
1st cycle	9.7	19.2	17.6
2nd cycle	5.7	Sample broke	9.2
3rd cycle	4.6	Sample broke	7.0

*ASTM—D 395-49T—Method B

Table 2—Properties of Cellular Elastomers

	Latex Foam	Polyurethane Foam	Polyurethane Expanded Type Sponge
Density, lb/ft³	6.8	4.0	3.0
RMA compression, lb	30.0	45.0	180
Flame resistance	Burns	Melts, resists burning	Burns slowly, melts
Tensile strength, psi	33.2	25.0	88.0
Elongation, per cent	455	250	240
Resilience, per cent	28.5	...	47.5

TORRINGTON *SPHERICAL ROLLER* BEARINGS



What a difference *conformity* makes!

TORRINGTON SPHERICAL ROLLER BEARINGS have the right degree of conformity between rollers and races and between roller ends and the center guide flange. "Skewing" is eliminated and rollers operate with a minimum of friction. This means even load distribution and long, low-maintenance service.

Because of their excellent performance in heavy-duty application, Torrington Spherical Roller Bearings have won wide acceptance in rock crushers, cranes, paper machinery, drilling rigs, presses—wherever high load capacity is required under conditions of misalignment.

Torrington Spherical Roller Bearings are available with either straight or tapered bore, for shaft or adapter mounting. And Torrington engineers have wide experience in custom-building bearings for special applications. Whenever you need bearings, call on TORRINGTON.

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Circle 572 on page 19

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle number on Yellow Card—page 19

Geared FHP Motors

No-base housing, brake equipped, wound reversing, tandem reversible, universal and right angle drive types of fractional horsepower geared motors are described in illustrated folder. Speed range is 1 revolution in 5 min to 700 rpm. Dimensional data and torque ratings are given. 4 pages. Merkle-Korff Gear Co.

Circle 401 on page 19

Plug Type Nuts

Hardened round Plug Nuts, bottom end of which is reduced in diameter and tapered, are described in illustrated bulletin. Pressed into a punched or drilled hole in ferrous or nonferrous material, their bottom section causes the material to flow into a groove in the nut. Selection data, installation instructions and fastener comparisons are included. 4 pages. Lamson & Sessions Co.

Circle 402 on page 19

High Vacuum Pumps

Advantages of radiator air-cooled lubricating system incorporated in two air-cooled rotary high vacuum pumps are related in bulletin 4356. They produce vacuums of 24 to 29.9 in. Hg with capacities of 15 to 40.8 cfm under continuous operation. 4 pages. Leiman Bros., Inc.

Circle 403 on page 19

Vibration Isolation

Vibration isolation efficiency curve printed in three colors is found in booklet 901, a guide to the selection of flexible mounting systems for equipment where noise and vibration control is desirable. Effects of mountings of different static deflections are shown. 4 pages. Lord Mfg. Co.

Circle 404 on page 19

Mill Bearings

Heavy duty mill bearings designed for industry's toughest operating conditions under severe radial and thrust loads are described and illustrated in booklet 2665. Self-aligning roller bearings in steel housings are for $2\frac{7}{16}$ to 11-in. shafts. 8 pages. Link-Belt Co.

Circle 405 on page 19

Silicone Rubber Stocks

Properties and applications for Silastic 50 and 80 general-purpose silicone rubber stocks are tabulated in bulletin 9-104. Parts fabricated of these materials withstand temperatures from −70 to 500° F. Uses include molded, calendered or extruded rubber; diaphragms, gaskets, seals and O-rings; and wire and cable insulation. 8 pages. Dow Corning Corp.

Circle 406 on page 19

Magnetic Drive

The Ampli-Speed adjustable speed magnetic drive can be used with an existing motor to get all the advantages of precise adjustable speed. Drive is practical for fan and pump applications or constant torque loads. Description is provided in bulletin 4400-PRD-229. 4 pages. Electric Machinery Mfg. Co.

Circle 407 on page 19

Instrument Transformers

Vital facts and figures on complete instrument transformer line, including the latest butyl-molded current types, are found in "1956 Instrument Transformer Buyer's Guide." Pertinent data and prices are included in publication GEC-1028. 80 pages. General Electric Co.

Circle 408 on page 19

Plastics Buying Guide

Complete data on all types of plastics, hundreds of different items and their uses, and unit and quantity prices are contained in illustrated catalog. This working guide for designers and engineers lists definitions, physical properties and buying information. 100 pages. Fry Plastics Co.

Circle 409 on page 19

Unit Type Annunciator

Advantages of the Electro-Larm unit type alarm annunciator for heavy-duty service in power stations and industrial plants are listed in descriptive folder. Alarm affords key positions of normal, alarm, pending and clear. Panel mounted unit is completely self-contained. 4 pages. Electro-Devices, Inc.

Circle 410 on page 19

Threaded Inserts

"Tap-Lok Self-Tapping Inserts" is title of illustrated data book which explains how these fasteners provide strong threaded connections in metals and plastics. Supplementary 2-page bulletin describes repair kit containing inserts and a manual driving tool. 12 pages. Groov-Pin Corp.

Circle 411 on page 19

Tubular & Solid Extrusions

Facilities for production of tubular and solid shapes of ferrous and nonferrous alloys are detailed in bulletin TB-413. The Ugine-Sejournet hot extrusion process is explained, and typical shapes are shown. 6 pages. Babcock & Wilcox Co., Tubular Products Div.

Circle 412 on page 19

Torque Converter

Performance and application data on the series 1500 single-stage torque converter are given in bulletin 508. Horsepower capacity range is 30 to 207 hp with speed range of 1100 to 2500 rpm. 4 pages. Twin Disc Clutch Co., Hydraulic Div.

Circle 413 on page 19

Hydraulic Cylinders

Engineering data and descriptions of hydraulic cylinders designated as Class 4 for 2000-psi service, are included in illustrated catalog 104. Parts cross sections, mounting brackets, rod clevises and special cylinders are also described. 12 pages. Galland-Henning, Nopak Div.

Circle 414 on page 19

General Purpose Pumps

Line of Class CRV cradle-mounted centrifugal pumps with capacities from 5 to 2800 gpm is subject of illustrated bulletin 7223-B. Heads range from 10 to 525 ft. Tabulation of ratings, performance table and dimensions aids in selection of required unit. 20 pages. Ingersoll-Rand Co.

Circle 415 on page 19

Bearing Material Selector

The proper material for sintered bronze or iron bearings is readily selected from multicolor "Bearing Material Chart." Clearly shown are chemical, mechanical and work characteristics of a wide range of sintered bearing materials. 4 pages. Bound Brook Oil-Less Bearing Co.

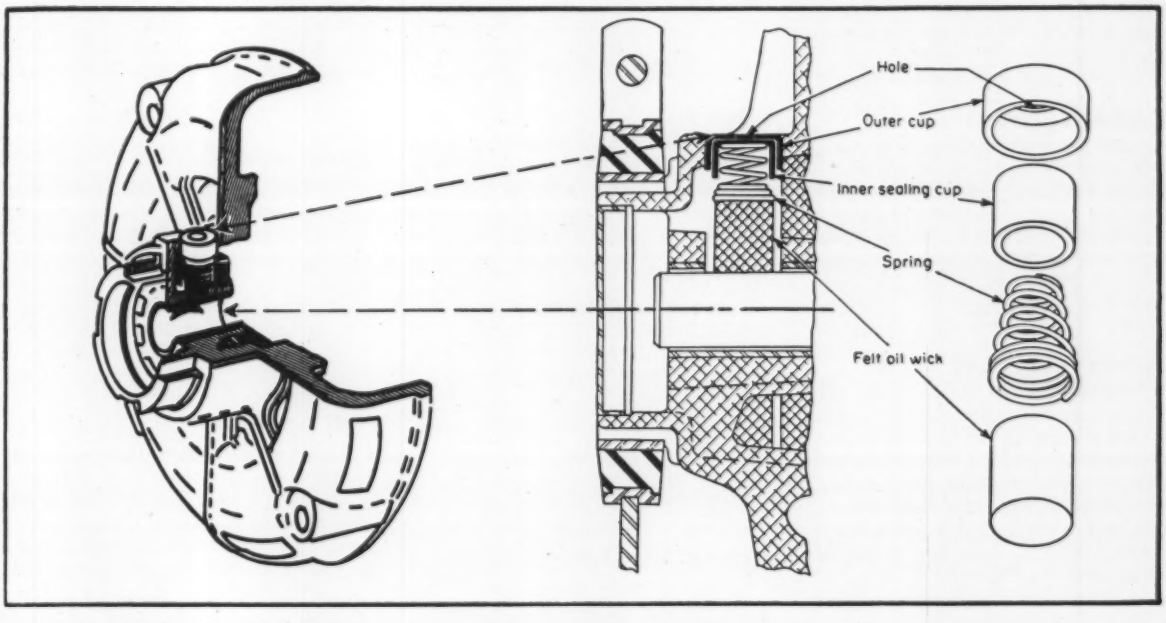
Circle 416 on page 19

Automation Components

Condenser catalog D-31 is described as a "convenient guide to ATC automation components and control systems for improving automatic opera-

Emerson-Electric engineering highlights

New, improved motor oiler assures positive, cleaner lubrication



A new-style oiler is a special feature included on many Emerson-Electric die-cast end-shield motors. It assures positive internal lubricating—also provides an added convenience in motor lubrication.

As shown in the illustration, the new oiler consists of three basic components—spring, retaining cup and oil-well cap. The spring performs two important functions:

First, it presses against a felt tongue which is part of the felt packing in the oil reservoir—the tongue extends through an opening in the sleeve bearing and makes direct contact with the shaft. By maintaining pressure against the tongue, proper lubrication is assured under all operating conditions.

Second, the spring holds the retaining cup in place against the oil-well cap; this prevents dirt and foreign matter from entering through the opening in the cap.

In addition, lubrication is simplified since pressure easily depresses the retaining cup, permitting oil to flow readily into the felt packing.

This is another of many Emerson Electric "highlight" engineering features that benefit designers and manufacturers of motor-driven appliances.

Call on Emerson-Electric motor-drive specialists

Recognized as a leader in equipment-drive motors for more than 60 years, Emerson-Electric specialists offer wide experience in all phases of motor-driven applications. You'll find their help valuable, whether you're designing or re-designing for performance and sales. Write for bulletin M-46. THE EMERSON ELECTRIC MFG. CO., ST. LOUIS 21, MISSOURI.

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BRANCHES: NEW YORK 7, N. Y., 11 Park Place • CHICAGO 23, ILL., 1623 S. Pulaski Road • SYRACUSE, N. Y., 209 Oakley Drive
PHILADELPHIA (Secane), PA., 868 Quince Lane • DETROIT 7, MICH., 1375 E. Jefferson Ave. • CLEVELAND 16, OHIO, 1580 Rockland Ave.
LOS ANGELES 42, CALIF., 5415 York Blvd. • DAVENPORT, IOWA, 617 Brady Street • CINCINNATI 11, OHIO, 2917 Ratterman Ave.

Circle 573 on page 19

tion." Design data are given on differential transformer systems, automatic control systems, time controls, motorized valves, control valves, counters and an electronic contactor. 20 pages. Automatic Temperature Control Co.

Circle 417 on page 19

High Vacuum Pumps

Six models of air-cooled compound high vacuum pumps are described in illustrated bulletin 403. They range from a ¼-hp unit with 2.0 cfm displacement to 3-hp unit with 46.0 cfm displacement. Each creates absolute pressures below 0.2-microns, McLeod gage. 4 pages. New York Air Brake Co., Kinney Div.

Circle 418 on page 19

Weighing Equipment

Eight separate data bulletins provide specifications and other information relative to production scales. The Selectrol automatic checkweigher capable of weighing up to 100 units per minute is featured in one of these bulletins. 2 pages each. Exact Weight Scale Co.

Circle 419 on page 19

Electrical Connectors

"What's New at Alden's" is title of brochure that shows a new series of single and multiple contact connectors for use in electrical and electronic equipment. These IMI connectors afford strain relief, seal against dust and moisture, have short leakage paths and reliability. 4 pages. Alden Products Co.

Circle 420 on page 19

Extruded Shapes

"Extrusions by Harper" booklet covers production of extrusions from stainless steels, heat resistant alloys, titanium, alloy steels, carbon steels and specialty bronzes. Production method using glass as a lubricant is described. 16 pages. H. M. Harper Co., Metals Div.

Circle 421 on page 19

Constant Delivery Pump

Twenty-one sizes of type C constant displacement radial piston pumps are described in illustrated bulletin 46000. Construction, operation, speeds, capacity and pressure ratings are included, along with views of custom-built reservoir units. 8 pages. Oilgear Co.

Circle 422 on page 19

Hydraulic Feed Controller

Designed to simplify fluid power application, provide fine feeds and high traverse speeds, Any-Feed Speed Paks are built in two 1000-psi and two 300-psi models. Illustrated bulletin 44200-A covers four oil flow diagrams, electrical circuits, typical machine cycles and other data. 12 pages. Oilgear Co.

Circle 423 on page 19

Slip Ring Assemblies

Slip ring assemblies designed to custom specifications are described in bulletin S-2056. Complete assemblies, brush holder assemblies (without ring), brush contacts on arms and brush contacts alone are covered. 4 pages. Superior Carbon Products, Inc.

Circle 424 on page 19

Hydraulic Power Units

Electrol Powerpaks and hand pumps which serve as control centers for hydraulic systems are subject of bulletin 102. Units operate at pressures up to 1500 and 1000 psi, respectively. 4 pages. Electrol Inc.

Circle 425 on page 19

Plastic Tubing

Tygon flexible plastic tubing, described in bulletin T-87, is offered in six standard formulations for a wide variety of fluid handling uses. Its properties, chemical resistance and other data, plus details of many applications are included. 28 pages. U. S. Stoneware Co., Plastics & Synthetics Div.

Circle 426 on page 19

Nickel & Alloy Tubing

"Superior Tube Nickel and Nickel Alloy Tubing" is title of comprehensive data guide No. 12 to these products. Expressly written for designers, engineers and purchasing executives, catalog lists properties, various analyses and typical applications. 20 pages. Superior Tube Co.

Circle 427 on page 19

Sealed Electric Connector

Description, specifications, mounting and clearance dimensions and other design data are given on series 1400 Continental electrical connectors in bulletin 48E. These components have six polarizing key positions and are hermetically sealed. 2 pages. DeJur-Amsco Corp., Electronic Sales Div.

Circle 428 on page 19

Hydraulic Components

Capsule descriptions of the Vickers line of airborne oil-hydraulic components and complete systems are found in catalog A-5200-D. Photos, drawings, selection tables and performance charts are included for variable displacement pumps, constant displacement motors, transmissions, servo pumps, relief valves and pressure regulators. 4 pages. Vickers Inc.

Circle 429 on page 19

Electric Heaters

"101 Ways to Apply Electric Heat" is an informative pocket-size booklet (F1550) that uses words and pictures to show applications of electric heat to water, oil, preheating fuel oil, heat transfer, generating and superheating steam, melting soft metals, melting ice and snow, cleaning and degreasing, and many other uses. 32 pages. Edwin L. Wiegand Co.

Circle 430 on page 19

Special Nuts

Details of milled-from-the-bar special nuts which feature close limits, eight or more slots, unusual drilling, special threads, precise tapering, counterboring, countersinking, special plating and/or heat treating are contained in illustrated folder. 4 pages. Wood & Spencer Co.

Circle 431 on page 19

Heat Exchangers

Single and multipass type F fixed tube bundle shell and tube heat exchangers are described in illustrated catalog 1254. Application data, materials and construction features, selection and performance data are given. 12 pages. Young Radiator Co.

Circle 432 on page 19

Miniature Couplings

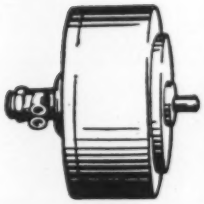
Standard and special miniature flexible couplings for power transmission are detailed in bulletin MC-100. Pictures and dimensional drawings of units for use on servomechanisms, computers and other small devices are included. Speeds up to 50,000 rpm are possible. 4 pages. Thomas Flexible Coupling Co.

Circle 433 on page 19

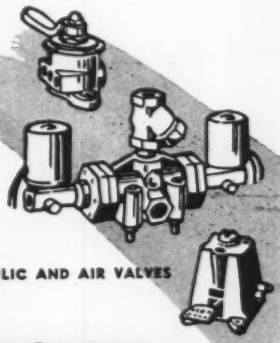
Stamped Gears

Revised form AF-3 catalogs Fastex precision stamped gears used for the transmission of motion and small amounts of power. Basic gear dimensional data, list of gears for which tooling is available and suggestions for design of gears requiring new tooling are provided. Diameters range up to 4 in. 32 pages. Illinois Tool Works, Fastex Div.

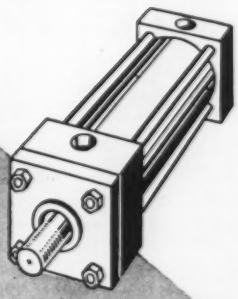
Circle 434 on page 19



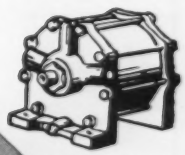
ROTATING AIR CYLINDERS



HYDRAULIC AND AIR VALVES



LOGANSQUARE AIR CYLINDERS



NONROTATING AIR CYLINDERS

specify . . . Logan

YOUR DEPENDABLE *"ONE-SOURCE"* SUPPLIER FOR ALL YOUR AIR AND HYDRAULIC EQUIPMENT..

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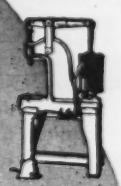
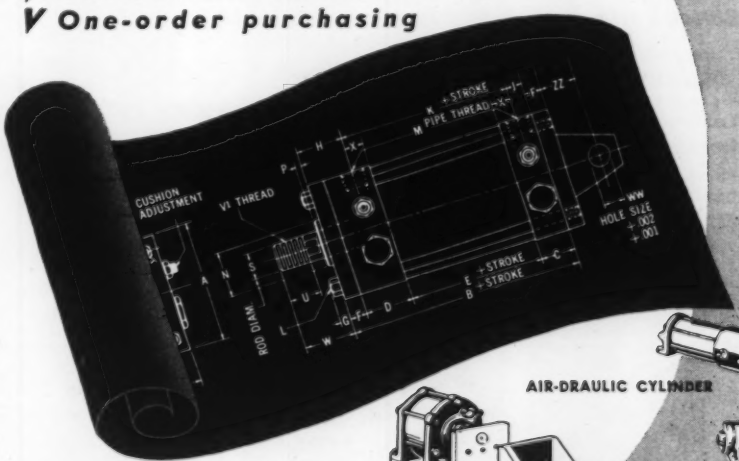
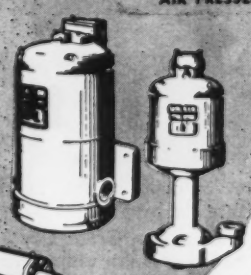
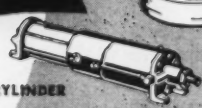
- ✓ *One-source manufacturing*
- ✓ *One-order purchasing*



HYDRAULIC AND AIR PRESSES

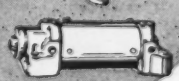




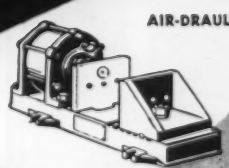


AIR-DRAULIC CYLINDER

SURE-FLOW COOLANT PUMPS



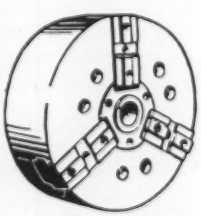
ROTOCAST HYDRAULIC CYLINDERS



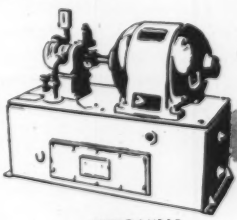
AIR-OPERATED VISES AND FIXTURES

MEMBER: Natl. Mach. Tool Builders' Assn., Natl. Fluid Power Assn.

RETURN THIS COUPON FOR FREE ENGINEERING DATA



AIR AND HYDRAULIC OPERATED CHUCKS



HYDRAULIC POWER UNITS

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PROPERLY EQUIPPED BY

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PLEASE SEND COPY OF CATALOG:

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- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 51 PRESSES
- ☐ FACTS OF LIFE
- ☐ 62 SURE-FLOW PUMPS
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 & 200-7 HYD. VALVES
- ☐ 200-6 SLIPPY-MATIC CYLS.
- ☐ 70-1 CHUCKS
- ☐ ABC BOOKLET
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TO:

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COMPANY _____

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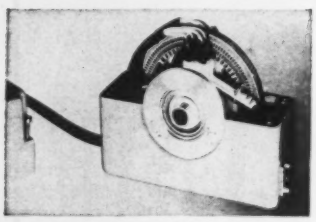
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Shaft Encoder

for speeds to 300 rpm

Low-inertia shaft-position encoder for analog to digital conversion lowers inertia reflected into a servo driving system from 423 gm-cm² to 235 gm-cm². Angular resolution is 0.3 deg or better. Auxiliary readout and translation units give readout at speeds up to



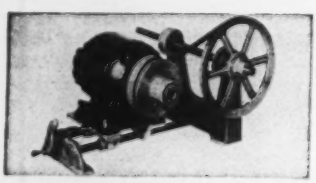
300 rpm or 300,000 quanta per minute. Unit is available with binary decimal code, Gray Code, or special codes. Dual units are available coded in 8421 binary decimal, pure binary, or excess three codes. **G. M. Giannini & Co.**, Datex Div., 918 E. Green St., Pasadena 1, Calif.

Circle 451 on page 19

Variable-Pitch Pulleys

in 3/4 and 1 hp capacities

Compact, light-weight variable-pitch pulleys are designed to be used with B-section V-belts. Discs are cast



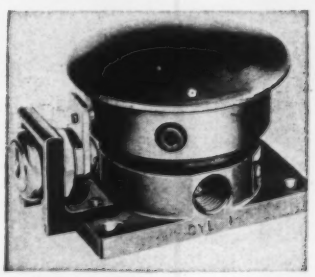
iron, smooth faced, noninterlocking, and nonserrated. Pulley has oil-impregnated bearings. Two models are available: Model 51 rated 3/4 hp at 1750 rpm with a 2.8:1 speed range, and Model 57 at 1 hp at 1750 rpm with a 2.3:1 speed range. Sizes are 5 in. diam by 3½ in. long, and 5 3/4 in. diam by 4 3/8 in. long. Bore sizes are 5/8, 3/4 and 7/8-in. **Gerbing Mfg. Corp.**, 11800 Milwaukee Ave., Northbrook, Ill.

Circle 452 on page 19

Button Valve

may be locked open or closed

Leak-proof palm-button valve is furnished either as a normally closed straightway or three-way hand-operated pilot valve. Valve can be provided with tumbler-type



lock, enabling valve to be locked in either open or closed position. Three-way model has a nonpiped exhaust, and both types have ¼-in. flow capacity. Overall height is 2 3/8 in. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit 3, Mich.

Circle 453 on page 19

Epoxy Resin Preform

for joining or potting dissimilar materials

Epoxy resin preform bonds without pressure by thermal setting at temperatures of 248 to 302 F. Preform bond joins and pots metal-to-metal, metal-to-nonmetal,

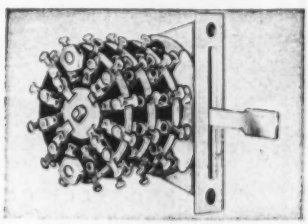
or nonmetal to nonmetal. Bond formed has high shear strength and low shrinkage. Preforms are made to customer's specifications. Application is for hermetic sealing, metal-to-ceramic joining, and sealing in lead wires and capacitors. **Atlas E-E Corp.**, 47 Prospect St., Woburn, Mass.

Circle 454 on page 19

Lever Switches

in subminiature size

Lever switches, subminiature in size, are available in two models: with and without return springs. Switch without spring return is designated series L-7000, switch with return spring is the series SRL-7000, providing return to center from two positions. One, two, or three decks and up to 4 poles per deck are available. Corrosion resistant construction is employed; silver alloy contacts are double wiping and self-cleaning. Rotor contacts are silver al-



loy, and are either make-before-break or break-before-make type. Dielectric strength is 1000 v rms; contact resistance is 0.006 ohms max; current carrying capacity is

Gardner-Denver workman inserting a Johnson sleeve bushing in a compressor piston.

Gardner-Denver Air-cooled Compressors are noted for quality all over the world.

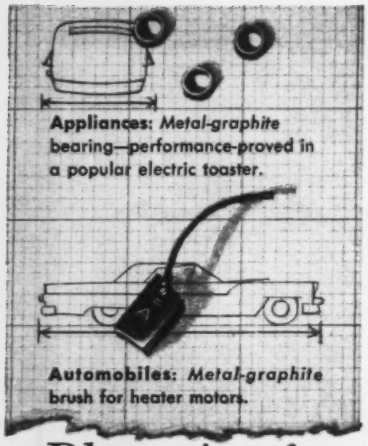
Johnson Bronze Sleeve Bearings Help Gardner-Denver Maintain Quality Standards

Since its founding in 1859, the Gardner-Denver Company has made it a policy to provide machines of the best possible quality. Under this policy the company has grown to be one of the world's largest manufacturers of air compressors and pumps. Contributing to the Gardner-Denver reputation for quality is the durability of the Johnson Bronze sleeve bearings which are incorporated in their products.

High quality Johnson bearings are used in some of the finest machinery being built today. Not only do they contribute to the high quality of the finished products, but they also facilitate production—for Johnson bearings are held to close tolerances and shipments are made on schedule. If you are having quality or delivery problems with your present bearings, let us show you how Johnson can help you. For detailed information, write Johnson Bronze Company, 525 S. Mill Street, New Castle, Pennsylvania.

Johnson Bearings

LEDALOYL (powder metallurgy) • ALUMINUM ON STEEL • BRONZE ON STEEL • STEEL AND BABBITT • CAST BRONZE



Appliances: *Metal-graphite* bearing—performance-proved in a popular electric toaster.

Automobiles: *Metal-graphite* brush for heater motors.

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Carbon — one of industry's most versatile materials—constantly finds new applications in the latest product designs.

Precision-molded carbon parts by Speer have improved product designs ...cut production costs—for hundreds of manufacturers.

Carbon Is Really Versatile!

Carbon can be:	Carbon has:
Sawed	High corrosion resistance
Drilled	High heat transfer
Milled	Low electrical resistance
Broached	High thermal shock resistance
Turned	
Planed	**Carbon is:**
Hobbed	Not wetted by molten metals
Ground	
Molded	Non-warping
Extruded	Chemically inert
	Self-lubricating

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Please send me information on:
— Molded carbon parts
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Address_____

City_____ Zone____ State_____

Circle 576 on page 19

New Parts

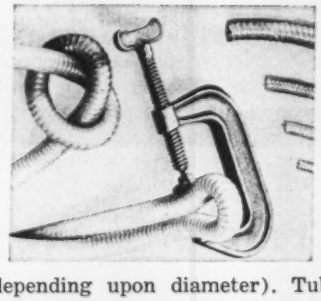
1 amp at 120 v dc, 800 ma at 115 v ac. Current breaking capacity is 400 ma at 50 v dc, 300 ma at 80 v dc, 250 ma at 120 v dc, and 200 ma at 115 v ac, noninductive. Applications are in miniaturized or transistorized test equipment and electronic equipment. **International Instruments Inc.**, New Haven, Conn.

Circle 455 on page 19

Flexible Plastic Tubing

is tensile spring reinforced

Bardex flexible tubing, reinforced by a tensile spring completely encircled by the plastic, is inert to gasoline, sea water, oils, coal and butane gas, and dilute acids. Working temperature is 5 to 170 F, pressure from 100 to 200 psi



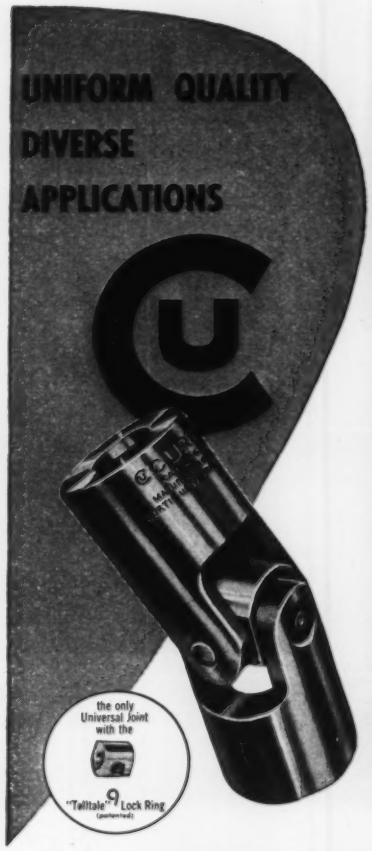
(depending upon diameter). Tubing sizes are ⅛-in. to 1 in. ID, lengths to two miles. Highly flexible and crush-proof, the transparent tubing is recommended for use with control equipment using photo-electric cells to regulate flow of liquids. **Newage International Inc.**, Bardex Div., 222 York Rd., Jenkintown, Pa.

Circle 456 on page 19

Coated Fabrics

resistant to fuel oils

Kel-F elastomer coated fabrics are resistant to corrosive chemicals, and swelling and deterioration in JP-4 and JP-5 fuels. Temperature limit for application of coated nylon fabric is 200 F; for coated Dacron limit is 400 F; and for coated glass fabric limit is 480 F for short periods, 400 F for extended periods. Coated nylon fabric cooled from −20 F to −85 F over period of four hours shows



Each part of every Curtis Universal Joint is made of specially selected steel, individually heat-treated for a specific purpose. This care in manufacture is reflected in our catalog torque and load ratings — which are substantiated by constant testing of production joints.

That's why Curtis Joints are the most dependable, durable and trouble-free available—the standard of the industry.

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- 14 sizes always in stock — bored or unbored hubs
- Fewer parts, simpler construction
- Complete equipment for government tests

PLUS — facilities and engineering skill to handle special specification jobs at any time.

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

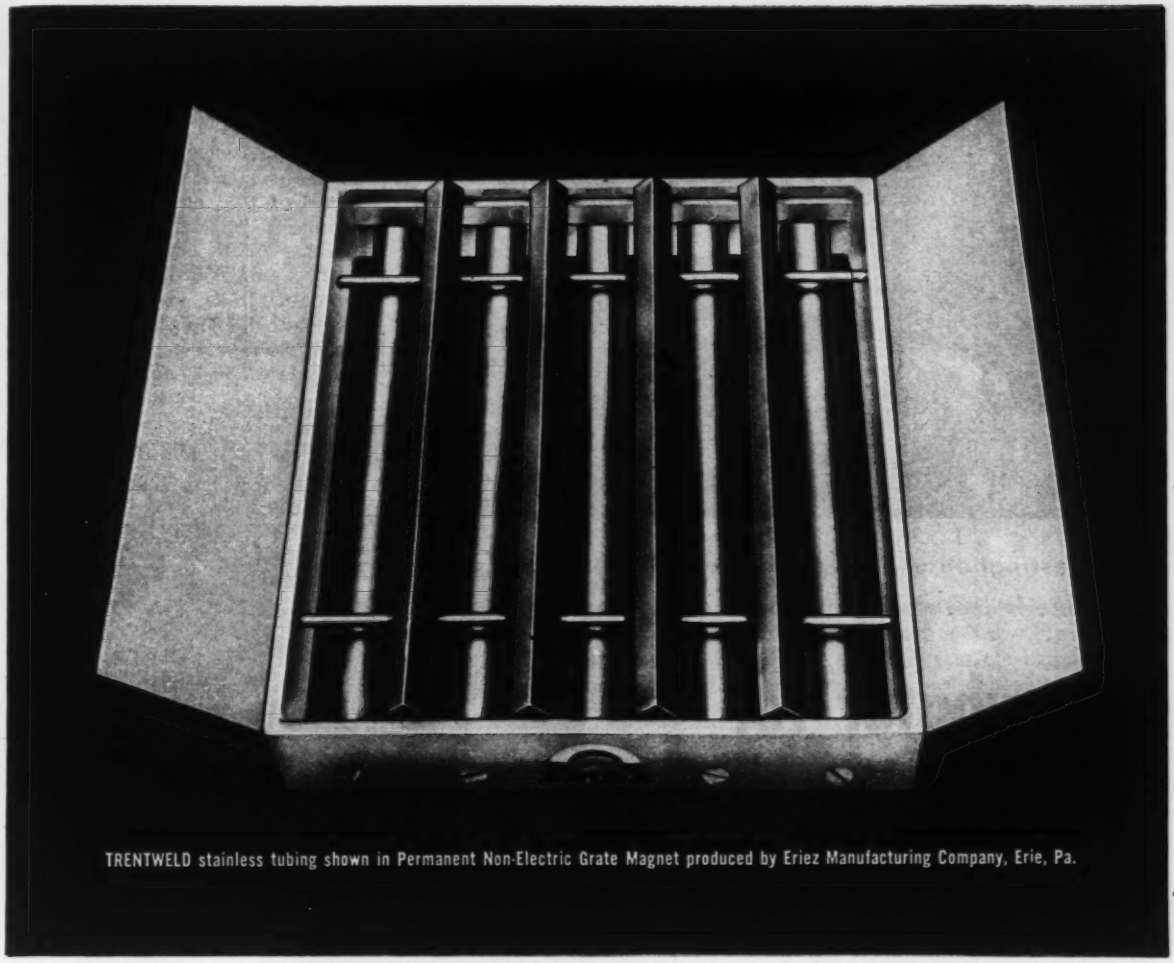
UNIVERSAL JOINT CO., INC.

5 BIRNIE AVENUE, SPRINGFIELD, MASS.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 577 on page 19



TRENTWELD stainless tubing shown in Permanent Non-Electric Grate Magnet produced by Eriez Manufacturing Company, Erie, Pa.

how TRENTWELD stainless tubing traps "tramp iron" in product flow...

As free-flowing products such as chemicals, grains, sugar or spices flow through this separator unit, large and small iron contamination is seized by powerful magnets and held firmly to the five stainless steel tubes.

This is a unit that's normally given long, hard use. That's why TRENTWELD stainless steel tubing is chosen to house the Alnico V magnetic elements. For stainless resists abrasion and corrosion . . . its smooth surface offers a minimum of resistance to product flow . . . and stainless is strong—lasts indefinitely. What's more, stainless is the easiest of metals to keep clean and sanitary.

And equally important to you is the fact that TRENTWELD is made by *tube mill specialists* —by the new, patented *Contour-Weld* Process. That means stainless pipe or tubing with a smoother I.D., free from any weld bead or undercut.

So when you need stainless or high-alloy pipe or tubing, make sure it's TRENTWELD. You can't buy better!

TRENTWELD

STAINLESS STEEL TUBING

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)

Westinghouse pilot plant for precision castings speeds development, saves capital investment

Incubator for casting ideas

To help you prove your precision casting ideas and developments under production conditions, Westinghouse invites you to use its new pilot plant facilities at Blairsville, Pa. Thus you can speed your metals programs without heavy capital investment.

Westinghouse will also assist you in creating prototype quantities . . . or give you fast, dependable delivery on production quantities of precision investment castings (lost wax process), shell-mold castings and powder metal parts.

Consider molded metal parts for your product components requiring intricate shapes, close tolerances, difficult machining operations or component assemblies. Westinghouse has skilled metals engineers with broad experience to help show you the way to improved products, lower costs.

Send today for further details and a copy of DB 52-500. Also enclose a photo, drawing or sample of the part you want evaluated. No obligation. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-05002

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***

Circle 579 on page 19

New Parts

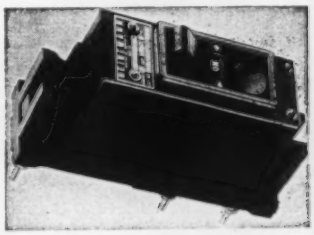
some change in flexibility, but no cracking in 180-deg bend test. Nylon fabric with thickness of 9-10 mils and weight of 11.8 oz per square yard has resistance to JP-4 fuel of 6.7 per cent increase in volume in 24 hours, 17.5 per cent increase in 96 hours. Resistance to JP-5 fuel is 1 per cent increase in volume in 24 hours, and 2.6 per cent in 96 hours. **Connecticut Hard Rubber Co.**, 407 East St., New Haven 9, Conn.

Circle 457 on page 19

Dual-Rated Circuit Breaker

trips at two current levels

Designed to operate on either of two voltages, for example, 6 and 12 v dc or 110 and 220 v ac, this circuit breaker has two current ratings, such as 2 and 4 amp, or 5 and 10 amp. Separate load connections are provided for each rating. Most ratings supplied have



current ratios of 2:1, but can be furnished in ratios up to 4:1. Rating is 1 amp minimum to 40 amp maximum. Breaker is available with one of three inverse time-delay characteristics, or with instantaneous trip. Maximum voltage is 480 ac, 125 dc. Operation is unaffected by ambient temperature. **Heinemann Electric Co.**, 572 Plum St., Trenton 2, N. J.

Circle 458 on page 19

Miniaturized Gears

have from 20 to 300 teeth

Miniature gears with 120 diametral pitch and 14½ and 20 deg pressure angle are available with from 20 to 300 teeth. Stainless-steel hub-type gears in precision class 1 and 2, have 20 through 120 teeth. Aluminum gears (24ST), in precision class 1 and 2, have 61 through 120 teeth. Aluminum gears with ⅛-in. face, available

Users of tubing for cylinder applications now you can have this new...

J&L Cold Drawn ELECTRICWELD

Tubing with a [redacted] ID Finish

Reduces your overall production costs in applications like these . . .

- **cylinder tubing**
- **hydraulic and pressure tubing**
- **shock absorbers**
- **ordnance components**

This new drawn-over-mandrel grade tubing with its mirror-like inside surface finish is today busy helping manufacturers reduce or entirely eliminate costly machining on many applications and is being substituted for more costly types of steel tubing. For example, it may be used, without inside honing, for many cylinders through which plungers are passed.

J&L Cold Drawn ELECTRICWELD Tubing with a *Special Smooth* ID finish combines the physical advantages imparted by today's modern electric welding techniques with those of cold working. It withstands high internal hydrostatic pressures, carries heavy torsion loads, resists high-frequency vibration, and offers a favorable weight-to-strength ratio for applications in which loading occurs in all directions.

J&L Cold Drawn ELECTRICWELD Tubing can be furnished in its three specifications in OD sizes from ½ inch to 2⅝ inches and in wall thickness from 20 to 10 gage, 0.035 and 0.134 inch respectively.

This new booklet provides the information you need . . . specifications . . . tolerances . . . chemistry . . . mechanical properties . . . annealing . . . finishes.

Send for your free copy today!

Jones & Laughlin Steel Corporation
Dept. 410, 3 Gateway Center, Pittsburgh 30, Pa.

Send me a copy of your new Cold Drawn ELECTRICWELD Booklet.

Name_____

Title_____

Company_____

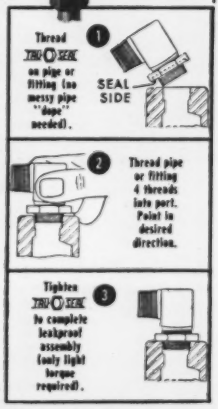
City_____ Zone____ State_____

XUM

PAT. PENDING

Prevents future leaks!

TRU-O-SEAL does away with messy pipe "dope" compounds, eliminates damage caused by overtightening of conventional leaky joints, and is immune to ALL known hydraulic fluids and to steam, air, water, solvents, and practically all gases and chemicals. It withstands temperatures from —100° F. to plus 500° F., saves cost and labor of special or welded fittings, and has been fully field tested and proven by leading manufacturers. Comes in ⅛" to 2½" pipe thread sizes.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Write for data and prices

TRU-O-SEAL DIVISION
Flick Reedy Corporation
2006 N. Hawthorne Melrose Park, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.

We invite you to see Our Exhibit at

BOOTH #1623
METAL SHOW
Oct. 8-12

PUBLIC AUDITORIUM CLEVELAND

Circle 581 on page 19

SHAMBAN KELON BACK-UP RINGS PROTECT O-RINGS IN ADVERSE CHEMICAL OR PHYSICAL ENVIRONMENTS

Write for Catalog

SHAMBAN KELON **ENGINEERING CO.**
11617 West Jefferson Blvd., Culver City, Calif.

Circle 582 on page 19

New Parts

hubless or with clamp or solid hubs, have 121 through 300 teeth in precision class 1. Bore range is 0.1200 to 0.1875-in. Stainless steel is passivated and aluminum is chromic acid anodized. **Dynamic Gear Co. Inc.**, Amityville, N. Y.

Circle 459 on page 19

Miniature Motor

has governor-controlled planetary gear train

Miniature motor has governor-controlled planetary gear train and integral filter. Designated the 1700-9-1, motor meets Noise Spec Mil-I-6181B. Load is 3 oz-in. Output speeds from 15 to 1800 rpm may be specified. Length is 2.912 in. from mounting flange, weight is 5½ oz. Uses include timing

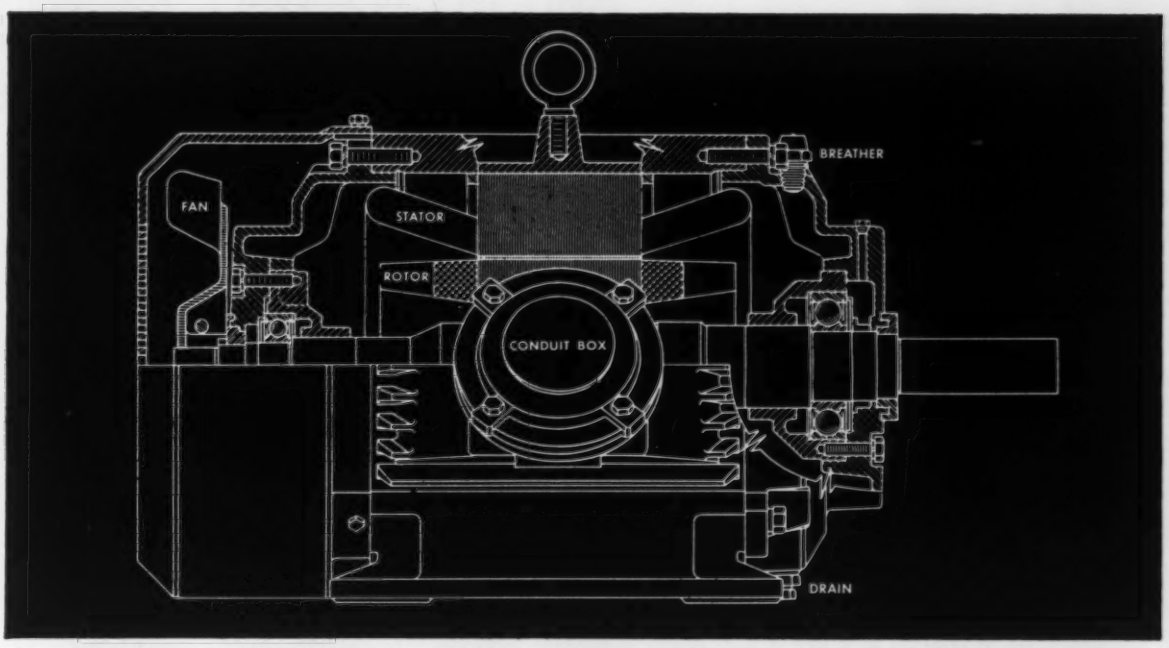
units for telemetering and commutator switching. **El Ray Motor Co., Inc.** 11747 Vose St., North Hollywood, Calif.

Circle 460 on page 19

Flexible Coupling

in miniature sizes from 1/8 to 5/16-in.

Miniature flexible coupling has die-cast aluminum or brass bodies and one-piece spider of Buna-N. Buna-N is equal to rubber in elasticity, strength, resilience, and resistance to abrasion but is superior in resistance to oils, chemicals, heat, ozone, and aging. Rating is 1/20-hp at 1750 rpm, range is 0.003-hp at 100 rpm to 0.103-hp at 3600 rpm. Dimensions are 5/8-in. OD by 3/4-in. long. Bore



THIS MOTOR CAN CUT YOUR HAZARDOUS ATMOSPHERE INSURANCE COST

Insuring facilities with electric motors in hazardous atmospheres is generally expensive or impossible without special motors. Reliance has developed a completely new, Underwriters' approved motor design, called explosion-proof, for hazardous locations. In fact this is the only motor design that meets all qualifications for class I, group D and class II, groups E, F and G without requiring modification.

This new motor incorporates all of the outstanding features of the standard Reliance Totally-Protected Motor. In addition, all Reliance Explosion-Proof Motors are built to corrosion-proof standards.

If you would like to have more information on what qualifies a motor for hazardous atmospheres, write for our new Explosion-Proof Motor Bulletin No. B-2409. B-1528

NATIONAL ELECTRICAL CODE CLASSES OF HAZARDOUS LOCATIONS

CLASS I —Those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Group D —Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohols, acetone, benzol, lacquer solvent vapors, or natural gas.

CLASS II—Those which are hazardous because of the presence of combustible dust.

Group E —Atmospheres containing dust of aluminum, magnesium, or their commercial alloys.

Group F —Atmospheres containing carbon black, coal or coke dust.

Group G—Atmospheres containing flour, starch or grain dust.

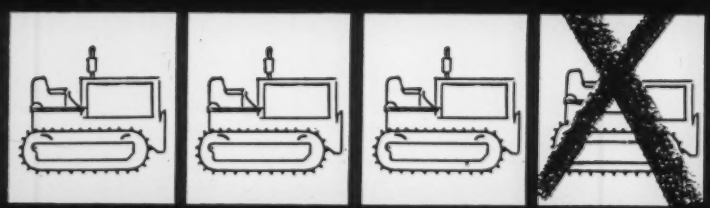
RELIANCE *Totally-Protected* MOTORS

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 288A, CLEVELAND 10, OHIO • CANADIAN DIVISION: WELLAND, ONTARIO

Sales Offices and Distributors in Principal Cities

With men who know converters best... it's Twin Disc 3 to 1!



For years, the construction industry has been the "proving ground" for heavy equipment. And the *toughest* jobs, under the severest conditions, have constantly been assigned to crawler tractors. That's why men who built and used crawlers were among the first to recognize the advantages of torque converter drive . . . and *are* the men who know converters best.

Today, the four manufacturers of the most powerful crawler tractors available all have torque converter equipped models. Of these, *all three of the "Big 3" volume producers*—Allis-Chalmers, Caterpillar and International Harvester—have special torque converter transmissions, in which they *standardize* on Twin Disc Torque Converter Components.

TWIN DISC CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois
Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa

Circle 584 on page 19

New Parts

sizes are 1/8, 3/16, 1/4, and 5/16-in. Applications include coding devices, film-type and tape recorders, actuators, dispensing machines and aircraft components. **Lovejoy Flexible Coupling Co.**, Dept. MDC, 4801 W. Lake St., Chicago 44, Ill.

Solenoid Valve

for liquids to 3000 psi

Leakproof rotary solenoid valve handles most fluids, including liquid oxygen and nitrogen, at pressures to 3000 psi. Light-weight

valve has straight through flow, and functions over wide temperature range. Available either normally open or normally closed, valve is supplied for ¼, 3/8 or ½-in. tubing size. **Pneu-Hydro Valve Corp.**, 364 Glenwood Ave., East Orange, N. J.

Floodlight

for high-vibration applications

Heavy-duty floodlight for heavy industrial applications involving vibration, has all-steel base with 2½ in. diam coil spring to absorb lateral and vertical vibration. A second shock absorbing spring is mounted directly behind the sealed beam lamp with a plunger shaft to release tension for removal and replacement of bulb. Inasmuch as sealed beam lamps require no reflector, the ¼-in. wall aluminum

Circle 585 on page 19→

EXCELLENT RECEPTION

leading television manufacturers select

to improve product construction and design

Sharon's family of high quality steels is finding "excellent reception" in the television industry.

For example, set designers concentrating on appearance and durability, are finding Sharonart* the ideal material. These rolled-in design patterns permit restyling without retooling.

To discourage rust and corrosion in the set itself, manufacturers like Galvanite* for this tightly-bonded, hot dip, zinc coated steel meets specification all the way.

Other Sharon steels popular with television parts manufacturers include Sharon Electrical Sheet used in transformers and motors; Sharon Tubing for antennas, and Sharon Spring Steels for fasteners.

*Trademark registered by Sharon Steel Corporation

SHARONSTEEL

SHARON STEEL CORPORATION

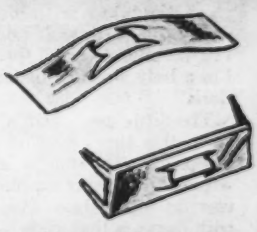
Sharon, Pennsylvania

DISTRICT SALES OFFICES: CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SHARON, MONTREAL, QUE., TORONTO, ONT.

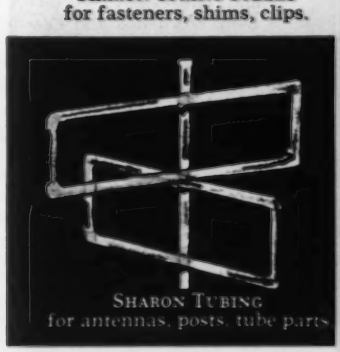
SHARON ELECTRICAL STEELS
for transformers, motors.

SHARON GALVANITE*
for chassis, rustproofed parts.

SHARONART
for panels, knobs, trim, etc.



SHARON SPRING STEELS
for fasteners, shims, clips.



SHARON TUBING
for antennas, posts, tube parts

SHARON STEEL CORPORATION MD-193

Sharon, Pennsylvania

Please send Sharonart Surface Rolled Patterns Steel brochure ☐ Galvanite booklet ☐
Sharon 430 Stainless Steel Folder ☐

Name_____

Position_____

Company_____

City_____ Zone_____

State_____

The abbot and the Musclebound File Clerk

The *abbot* studied the snapshot sympathetically and read the scented letter. "You must help me, kind sir," it pleaded. "For years I've struggled with overloaded, sticky file drawers. Look at me! I'm so musclebound people think I'm a lady wrestler instead of a file clerk."

The little man had a ready answer, this time. Seating himself at his photo-electronic typewriter, he wrote, "Ask your employer to invest in up-to-date files equipped with drawers that glide — smoothly and effortlessly — on ABBOTT *Deep Hardened* and *Tempered* carbon steel bearing balls. They open and close at the touch of a finger!"

Abbott bearing balls have unlimited uses because they possess great shock resistance and perform efficiently under high load factors. These *special* properties come from Abbott's unique manufacturing processes and quality control which amply justify the name . . . ABBOTT — "the Ball with the Armored Heart".

Have you a knotty problem which the abbot may solve with his vast knowledge of "The BALL — its nature and applications"? Write him about it at . . .

ABBOTT

The ABBOTT BALL Company

50 Railroad Place, Hartford 10, Conn.

Circle 586 on page 19

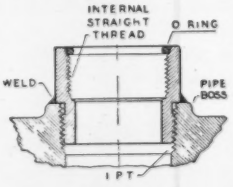
New Parts

housing around the lamp is only for protection. Four 120-v models are available with ratings of 150 through 500 w. Also available are 28-v units which have built-in resistors to absorb voltage differential when operated on 32-v systems. Applications are on earth-moving equipment, tractors, trucks, cranes, etc. **A & A Mfg. Co. Inc.**, 2017 W. Clybourn St., Milwaukee 3, Wis.

Thread Adapter

for pipe to straight thread

Adapter is for use on valves and similar units with pipe threads to enable use of straight-thread tube fittings. Design allows welding after adapter is in place to

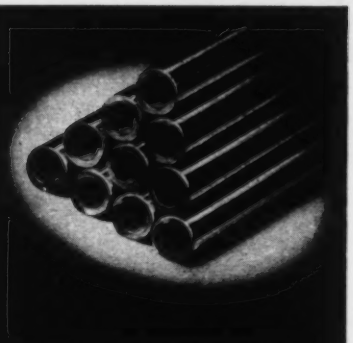


form a permanent leak-proof joint. **Parker Appliance Co.**, Tube & Hose Fittings Div., 17325 Euclid Ave., Cleveland 12, O.

Magnesium-Thorium Sheet

for high-temperature applications

Elevated temperature magnesium alloy sheet contains thorium, zirconium, and manganese in various combinations. Alloy retains good short-time properties up to 800 F, and good long-time properties to 600 F. Material is corrosion resistant, and because of light weight, may be used in relatively



LOOK NO FURTHER FOR QUALITY. . .

Bishop small diameter stainless steel tubing is not surpassed in meeting corrosion, heat, shock, stress and vibration.

It is not excelled in quality of starting stock . . . in accuracy of I.D. and O.D. . . . in dimensional precision . . . in finish.

When quality is of prime importance, for hydraulic lines, for aircraft parts, for instruments, for electronics . . . in fact wherever high quality steel tubing is indicated, look to Bishop for the finest . . . at comparable prices.

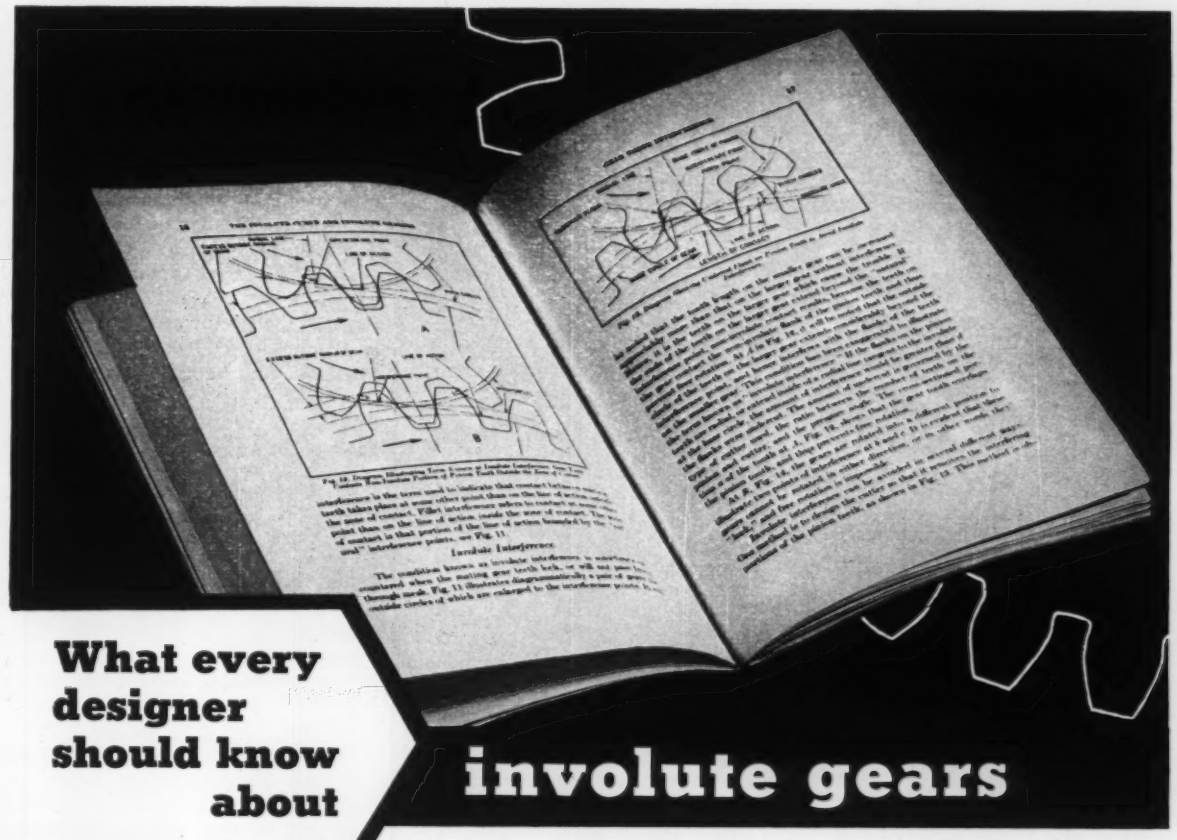
CAPILLARY, MECHANICAL, HYPODERMIC and AIRCRAFT Stainless Steel Tubing . . . seamless and welded and drawn (.008" to 1.000" O.D.) (.003" to .083" Wall) Nickel and Nickel Alloy Tubing (up to .625" O.D.)

Catalog on Request

JB **J. BISHOP & CO. PLATINUM WORKS**

Stainless Steel Products Division
Malvern, Pennsylvania
Established 1842

Circle 587 on page 19



What every designer should know about involute gears

The properties of the involute curve as a gear-tooth profile offer many possibilities in the design of gears. To take full advantage of them, you must know the three basic elements of gear design and the fundamental laws of the involute curve.

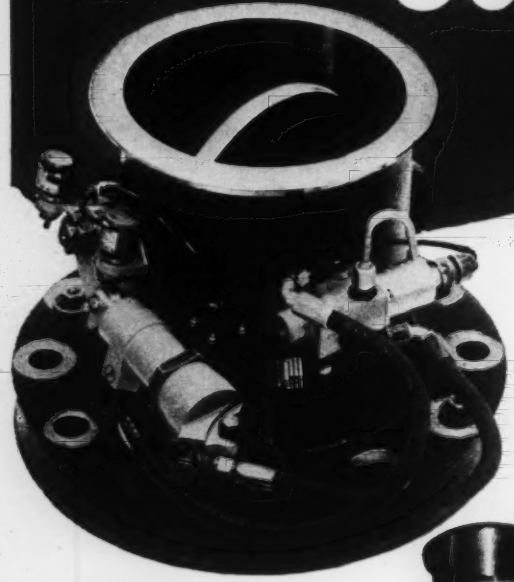
These are stated in "The Involute Curve and Involute Gearing," a complete treatise on Involute Gear Design. The contents of this booklet also include such useful subjects as the function of gearing, the application of the involute to gear teeth, the Gear Shaper Cutter, generating involute gears on the Fellows Gear Shaper, checking profiles on Fellows Involute Measuring Instruments and definitions of gear tooth elements. A copy is yours for the asking. Just write any Fellows Office.

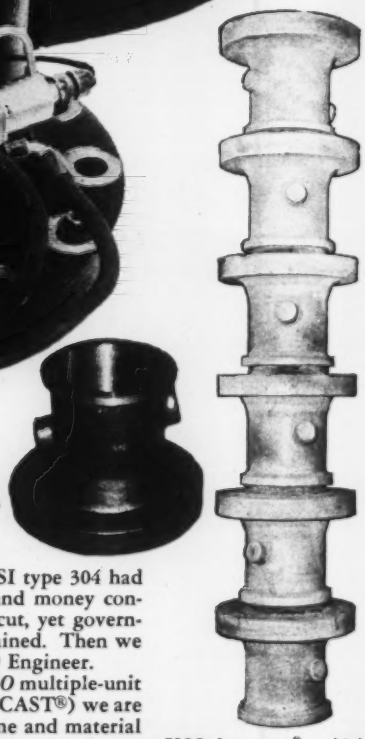
You should also know that in addition to providing speed and accuracy in generating involute gears, the Fellows Gear Shaper provides an economical means for generating many non-involute shapes such as sprockets, cams and other irregular contours.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 319 Fisher Building, Detroit 2
5835 West North Avenue, Chicago 39
150 West Pleasant Avenue, Maywood, N. J.
6214 West Manchester Avenue, Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*

"ESCO SPUNCAST® SAVED US 30%





...in the cost of producing guided missile components"

"Heavy butterfly valve bodies of AISI type 304 had previously been fabricated, a time and money consuming operation. Costs had to be cut, yet government specifications had to be maintained. Then we discussed our problem with an *ESCO* Engineer.

"Today, by taking advantage of *ESCO* multiple-unit centrifugal casting technique (SPUNCAST®) we are able to effect an overall saving in time and material amounting to 30% of our previous costs," says top engineer of Interstate Engineering Corporation, leading missile component manufacturer at El Segundo, California.

Whether your problem is one of heat, corrosion, impact, abrasion or alloy availability, the *ESCO* Engineering staff will help you plan for greater savings in time, material and money.

ESCO Spuncast® multiple casting "stick" technique produces six butterfly valve bodies at one time. After parting from the "stick" each valve body weighs approximately 180 pounds as cast.

WRITE FOR FREE BOOKLET

ELECTRIC STEEL FOUNDRY COMPANY

ESCO

Manufacturing Plants
2183 N. W. 25th Ave., Portland 10, Oregon
1017 Griggs Street Danville, Illinois

ESCO International — New York Office
at 420 Lexington Ave., New York City, or Portland Manufacturing Plant

Other Offices and Warehouses
Los Angeles, San Francisco, Calif. Seattle, Spokane, Wash. Houston, Texas Eugene, Oregon Salt Lake City, Utah Honolulu, Hawaii

In Canada, ESCO Limited
Vancouver, B. C., and Toronto, Ontario

Circle 589 on page 19

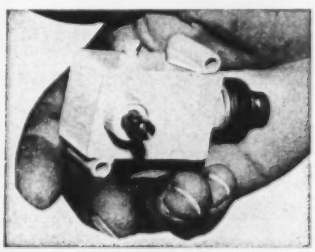
New Parts

thick sheets which resist buckling better than thinner sheets of heavier metals. Sheet is available in production quantities rolled in gages from 0.016 to 2 in. in hard-rolled (−H24) and annealed (−0) conditions. Primarily for aircraft development projects, alloy may be sheared, drawn, spun, arc welded, and spot welded. Severe drawing may be performed in temperature range of 600 to 700 F. **Dow Chemical Co.**, Midland, Mich.

Rotary Switch

is rotary actuated, hermetically sealed

A flexible seal, formed of a silastic compound, hermetically seals this rotary actuated switch. Seal has low leakage rate, less than one micron per cubic foot per hour, effectively sealing the switch against water, ice, vapor, and dust. Tem-



perature range is −100 F to +250 F. Switch may be wired externally from single-pole, single-throw to double-pole, double-throw, four-circuit, enabling four isolated circuits to be switched at one actuation (two normally open, two normally closed). **Electro Snap Switch & Mfg. Co.**, 4218 W. Lake St., Chicago 24, Ill.

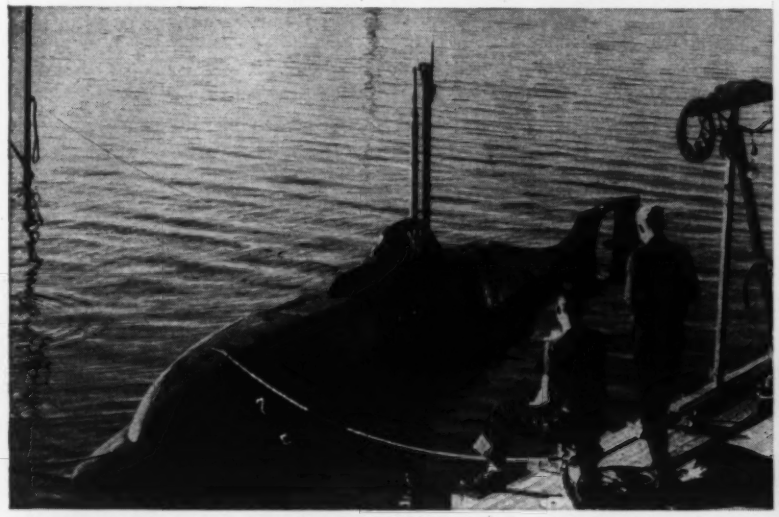
Split Nut

is locked in place with pliers

Slip-Squeeze, a nut of aluminum alloy, has one side machined away to allow placing on threaded rod when end is inaccessible or at a distance from desired point of application. Nut is positioned and squeezed tight with pliers. Representative application is holding templates rigid while plaster mock-

★ Control Components Digest ★

News and notes on resistors, rheostats, relays, motor controls, dimmers and other control components



FIRST TEST DIVE, on a leash, for new midget sub. Fairchild engineers stand by. She passed this and other tests and was turned over to Navy.

New 4-man midget sub joins Navy

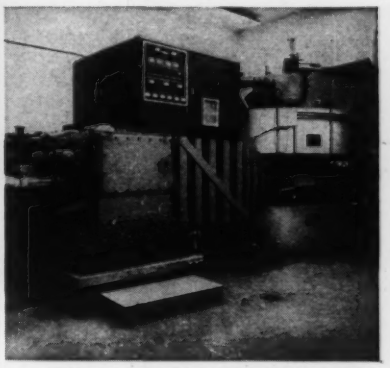
Only 50 feet long, but packing a mighty wallop, the USS X-1, a new midget submarine has just been preliminarily accepted by the U. S. Navy from the builders, Fairchild Engine Division of Fairchild Engine and Airplane Corporation, Deer Park, Long Island.

The 25-ton X-1 carries a 4-man crew, can dive under or cut through steel nets protecting harbors, and sneak up rivers and canals to attack power plants, bridges and dams.

And, among the many design features contributing to the striking power of this new Naval weapon, you'll find reliable Ward Leonard controls for the electric drive—just one of the ways Ward Leonard products are aiding national defense.

75-ton shield door gets fingertip control

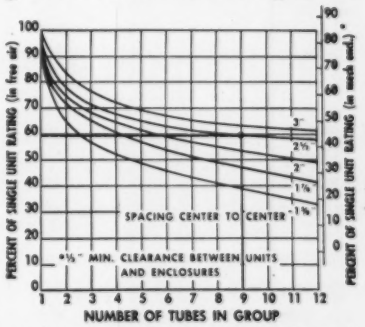
Centralized Ward Leonard motor controls slide the massive shield door for this modern cyclotron into place for research experiments at Brookhaven National Laboratory, Upton, Long Island, N. Y.



Made of concrete with steel support, and weighing 75 tons, the 5- by 8- by 12-foot door protects personnel from effects of radiation when deuterons (the nuclei of heavy hydrogen) are accelerated to an energy of 20 million electron volts.

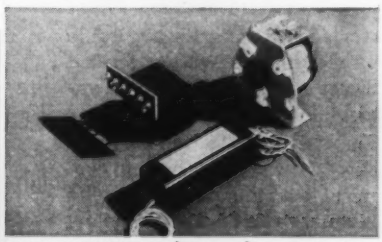
Easy derating for group-mounted resistors

This family of curves will help the designer allow for mutual heating of resistors mounted in close proximity. It's typical of the practical design data you'll find in Ward Leonard's 65-page Catalog 15. Write for your free copy today. 6.8



100% inspection here!

No statistics, no probability theory in this 100% check! She's measuring OD and concentricity of ceramic resistor cores—just two details in Ward Leonard's rigorous and continuous quality control. But, it's checking details like these on every single unit that gives Ward Leonard products their reputation for accuracy, stability and long life.

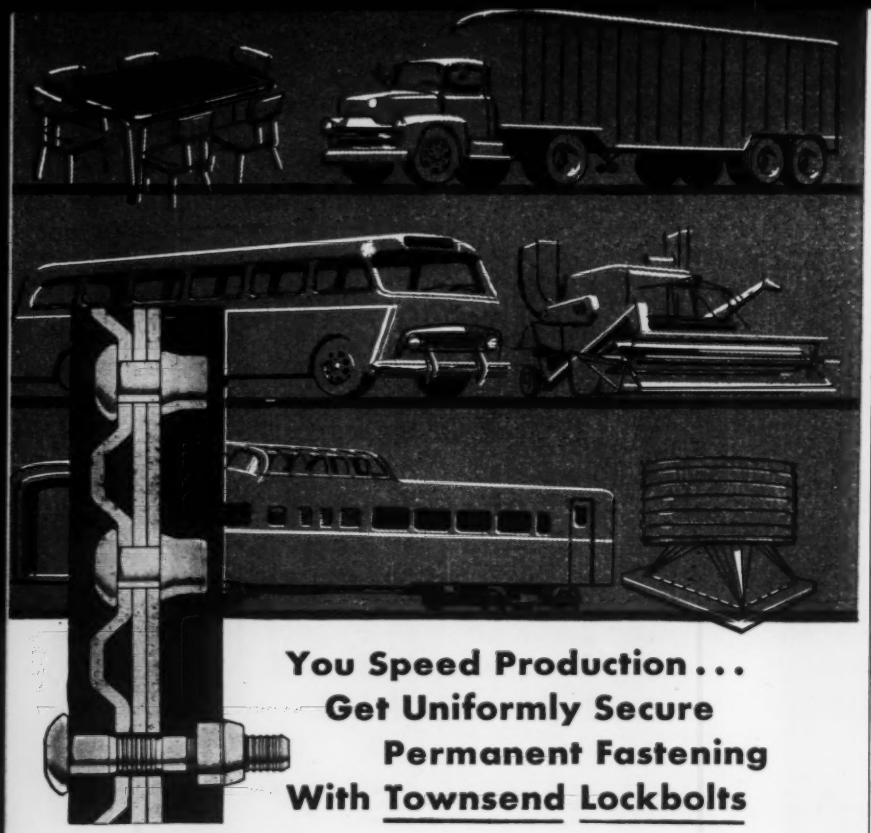


BASIC COMPONENTS for new dimming system.

New 500-to-1 dimmer for fluorescents

A new Ward Leonard dimming system for hot-cathode 40-watt T-12 fluorescent lamps handles up to 140 lamps with a dimming range of 500 to 1. Simple and non-electronic, the new dimmer is designed for control of cove lighting, luminous ceilings and multiple lamp fixtures in theatres, auditoriums, churches, offices, restaurants, and night clubs. Dimmer circuit output is unaffected by change in connected lamp load. For complete data, write for bulletin 76F.

WARD LEONARD ELECTRIC COMPANY
58 SOUTH ST., MOUNT VERNON, N. Y.
Result-Engineered Controls Since 1892
RESISTORS · RHEOSTATS · RELAYS · CONTROLS · DIMMERS



You Speed Production . . . Get Uniformly Secure Permanent Fastening With Townsend Lockbolts

The Townsend lockbolt provides a quick method of producing uniformly secure fastenings that cannot loosen even under extreme vibration or shock conditions. They combine the advantages of riveting and bolting—eliminate the disadvantages.

Typical users are manufacturers of railroad cars, highway trucks and trailers, buses, farm equipment, industrial ventilators, and furniture. They find that the use of Townsend lockbolts gives them an opportunity to improve their products—reduce unit costs.

These benefits are possible for several reasons. By use of Townsend lockbolts, fewer and less skilled workers can complete an assembly faster than by other methods because the setting action does not depend upon the skill of the operator. The clamping action, or tensile preload is higher than rivets—is more uniform than bolts and nuts. The lockbolt makes possible a more rigid joint because it fills the hole better than other fasteners.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16", 3/8" and 1/2" diameters, in grip lengths ranging up to 2" in various head styles. Other material and lengths available upon request. They are described in Sweet's design file and in Townsend bulletin TL-101.

For a demonstration at your desk of how to get better, economical fastening with Townsend lockbolts, write on your company letterhead to Townsend Company, P. O. Box 237-E, New Brighton, Pa.

Licensed under Huck patent nos. RE 22,792, 2,114,493; 2,527,307, 2,531,048; 2,531,049, 2,754,703

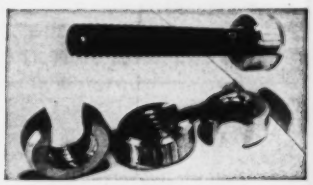
Townsend

COMPANY • ESTABLISHED 1816

Sales Offices in Principal Cities

Circle 591 on page 19

New Parts

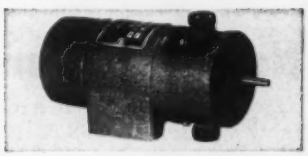


ups are being sculptured. A wide range of sizes is available. **Nutt-Shel Co. Inc.**, 811 Airway, Glendale 1, Calif.

Tachometer Generator

is self-compensated against temperature variation

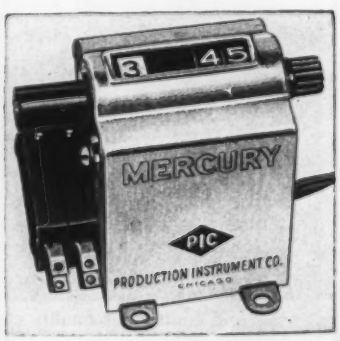
Available in one of two basic models based upon amount of compensation desired, new dc tachometer generators hold output variation to less than 0.1 per cent, and voltage variation to less than



0.25 per cent, within temperature range of −40 C to +100 C. External compensating networks are eliminated. Generators are available in six frame sizes and mounting types. Outputs are from 1 to 175 v per 1000 rpm, with operating speeds up to 10,000 rpm or higher. **Electric Indicator Co.**, 100 Camp Ave., Springdale, Conn.

Batch Counter

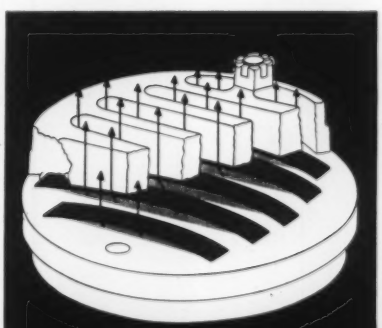
counts to 900 units



Small electric batch counter is easily preset to count any quantity to 900 and then operate an electric

Circle 592 on page 19→

This compressor valve works with no impact for longer life, best efficiency



Stainless steel strips, in red, open the Feather Valve ports by rolling contact against the lower plate. There is no impact.

The Feather* Valve is the lightest, simplest, quietest compressor valve ever developed. Flexible strips of stainless steel open and close the valve ports with a gentle rolling contact. There is no destructive impact . . . even when the valve is operating as fast as forty times a second.

This lack of impact assures long life and negligible maintenance. The valve itself is all but indestructible. Absence of buffer plates and cushioning devices give it extreme simplicity.

The Feather Valve is quiet and reliable because of its lightness and tight contact seating. Valve action is very sharp. There is virtually no slip or back flow. As a result, you get minimum valve loss and use minimum power.

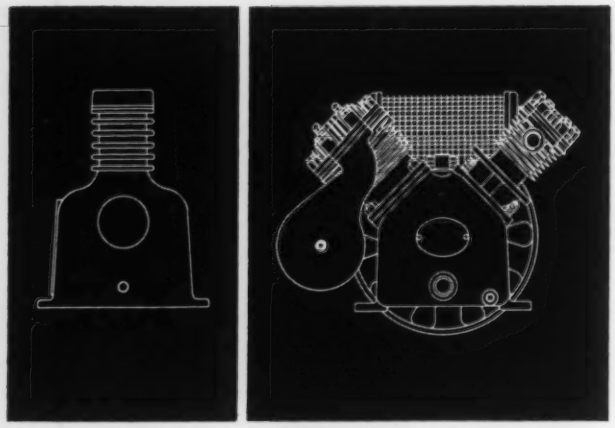
To get the utmost in performance, be sure you specify Worthington when you buy your next compressor. Worthington Corporation, Harrison, N. J. K.6.2

WORTHINGTON

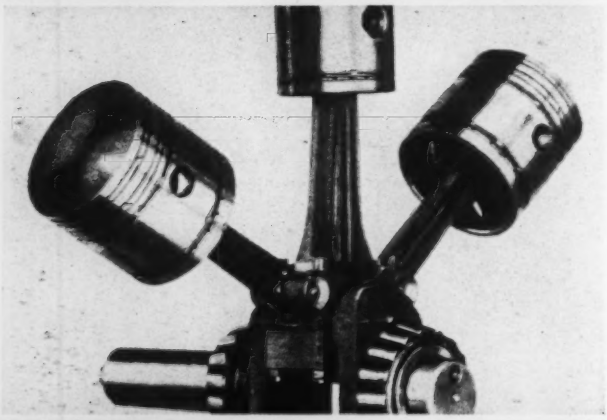
*Reg. U. S. Pat. Off.

WHAT'S YOUR C.Q.?*

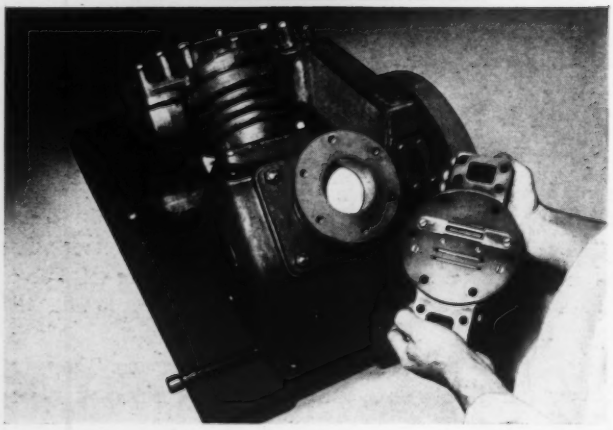
*COMPRESSOR QUOTIENT



In-line or V-type—which is more efficient? In certain fields, this is a hotly debated subject. In compressors, however, most authorities agree that the V-type design provides better balance, smoother running, and better cooling. Besides building only the more efficient V-type design, Worthington casts each cylinder separately from the crankcase. Air thus flows completely around the isolated cylinders, increasing efficiency and saving power dollars.



Why is this connecting rod "aerodynamically" sound? This articulated connecting rod design assures smooth effortless operation, less bearing wear and longer life. It's used in all Worthington radial compressors because it lowers crankpin bearing pressure. One large bearing carries peak connecting rod loads which occur at successive intervals. It's aerodynamically sound because the design is also used in all modern radial aircraft engines.



What important maintenance feature is he demonstrating? When a compressor is operating, valves open and close as many as thirty-three times a second. Valve maintenance is therefore of major concern to all users. Unlike many other makes which require replacement of the complete cylinder or head, all Worthington compressors are equipped with individually replaceable valves and valve guard seats. This is just one of the many Worthington features which save you time and money.

PC. 6.4

To increase your C. Q., write today for the complete story on Worthington's line of standard compressors. Ask for bulletins H-630-B1 and H-605-B3C. Address Section PC64, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Air Compressors • Pumps • Multi-V-Drives • Allspeed Drives

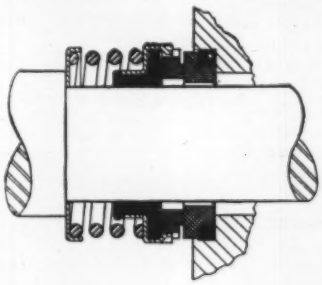
switch. Counter registers each unit counted. Overall dimensions are 2 3/4 wide by 2 1/4 deep by 2 27/64 high. **Production Instrument Co.**, 702-08 W. Jackson Blvd., Chicago 6, Ill.

Circle 469 on page 19

Grommet Seal

for shaft mounting

Series 4000 grommet seal is available with a wide range of mating face and sealing materials to withstand all liquids, including those with abrasive particles. Metal components may also be varied to



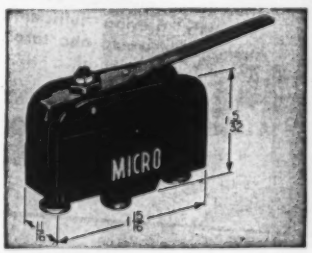
suit application. Close hydraulic balance permits leak-proof operation under high liquid pressures. Range of six shaft sizes is from 3/8-in to 1 in. **Cartriseal Corp.**, 3515 W. Tougy Ave., Lincolnwood, Ill.

Circle 470 on page 19

Basic Switch

has adjustable operating lever

Basic switch has adjustment for position of operating lever between 0.670 and 0.880 in. Adjustment



is by means of a screw, and may be made without dismounting switch. Switch is available with straight or formed lever, with or without roller, and solder type or screw terminals. Contact is single-

(*Continued on Page* 178)

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for heavy duty industrial applications

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DUST TIGHT
OMNIDIRECTIONAL

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City_____ State_____

Circle 593 on page 19

AN ALUMINUM COST

This cost savings story points the way to big economies for you!

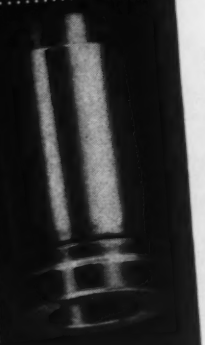
PART I

CAMERA TRIPOD PART Converted from steel to aluminum. Cost savings per 1,000 parts . . . 38.4%

...based on material and production costs per part of $1.90 for steel and $1.17 for aluminum. Figures given do not include the cost necessary for plating had steel been specified. Because of aluminum's attractive finish and resistance to rust, anodizing was the only finishing operation required. This part is one of a number of different aluminum parts used in the camera tripod.

PART IV

BUSHING — Converted from brass to aluminum. Cost savings per 1,000 parts . . . 53%



Lower raw material costs were entirely responsible for these savings. Only 22 pounds of aluminum at $.56 a pound were required for 10,000 parts. Brass, however, required 67 pounds for the same job. At $.42 a pound, the total cost for brass was $28.14, less $4.58 for scrap recovery. Aluminum's total cost was $12.66 for every 10,000 parts produced.

PART V

WINDSHIELD WIPER KNOB INSERT — Converted from brass to aluminum. Cost savings per 1,000 parts . . . 24.8%

Because of the savings offered by aluminum, engineers tested it along with other materials for this particular application. They found aluminum would not only provide sufficient strength but would also take a slightly better knurl.

SEE "THE KAISER ALUMINUM HOUR" Alternate Tuesdays, NBC Network. Consult your local TV listing.

STORY IN FIVE PARTS

PART II

NOZZLE — Converted from brass to aluminum. Cost savings per 1,000 parts. . 24.9%

Set up time and labor costs were equal between brass and aluminum. But brass required 32.4 pounds for 1,000 nozzles while aluminum required only 10.66 pounds. The difference in material cost, therefore, was $7.86 or 24.9% saved per 1,000 parts in lots of 10,000.

PART III

INSERT — Converted from steel to aluminum. Cost savings per 1,000 parts. . . 35%

Cost savings on this part were due to lower machine time and not raw material costs. Aluminum's faster machinability permitted a two-third reduction in machine time per 1,000 parts.

HOW YOU SAVE WITH KAISER ALUMINUM

The five companies whose parts are shown here — like parts buyers all over the country — have discovered that Kaiser Aluminum stock can give them big savings and better quality.

You get *three times* as many parts from a pound of lightweight Kaiser Aluminum stock as from a pound of brass or steel. Thus, each part can cost far less.

And you often get *better* parts because aluminum provides a unique combination of useful advantages, including lightness with strength, handsome finish, corrosion resistance, good heat and electrical conductivity.

For more information or assistance, look for our local number in the classified telephone directory under the heading "Aluminum." Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum

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Technical Editor,
Kaiser Aluminum & Chemical Sales, Inc.,
909 N. Michigan Ave.,
Chicago 11, Illinois

Please send, without obligation, my copy of "Machining Kaiser Aluminum" which I understand is a hard-cover, library volume containing information of value to me when designing with aluminum.

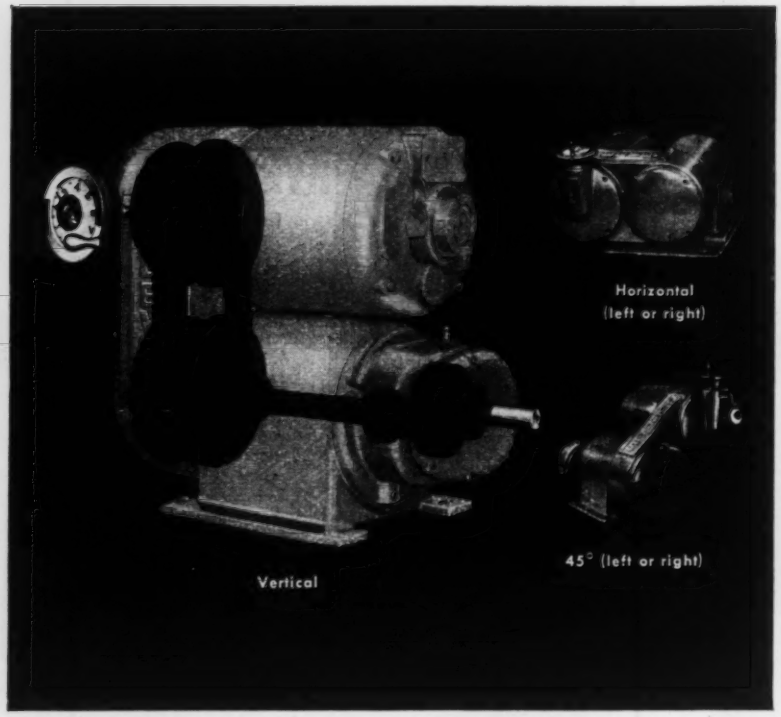
Name _____ Position _____

Company _____

Address _____

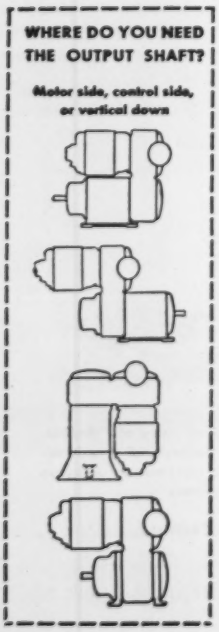
City _____ State _____

Variable Speed—Styled For Compact Machine Designs



REEVES

FRACTIONAL *Vari-Speed* MOTODRIVE



▶ REEVES fractional hp. Motodrive is a complete power package, engineered in over 100 assemblies to fit wherever your design calls for variable speed.

Choose from vertical, 45° or horizontal models in ¼ to 1 hp. . . . get stepless accurate speeds—within a 2:1 to 10:1 range—from as low as 3 rpm to a maximum of 4660 rpm.

Available in standard, weather resistant, totally enclosed or splash-proof enclosures; full range of manual or automatic controls.

REEVES Motodrive—the *right* speed for *every* need . . . in *any* place.

Write Dept. H23a-M543 for ratings and dimensions.

REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
Columbus, Indiana

Circle 595 on page 19

New Parts

(*Continued from Page* 175)

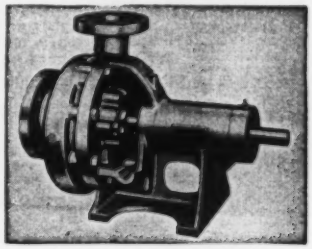
pole double-throw, or split-contact double-throw. Ratings are 15 amps 125, 250 or 460 v ac; 0.5 amp 125 v dc, 0.25 amp 250 v dc. **Minneapolis - Honeywell Regulator Co.**, Micro Switch Div., Freeport, Ill.

Circle 471 on page 19

Centrifugal Pump

for chemical processing

Moderate capacity pump for chemical process liquids is available in two types: Type DL is grease-lubricated for liquids to 250 F:



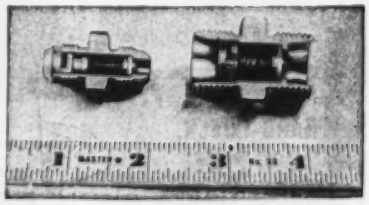
Type DM is oil - lubricated for liquids from 250 F to 400 F. Complete interchangeability of components enables user to select frame, backplate, impeller, volute, and materials to suit any application. Discharge sizes are from 1 to 4 in., capacities to 800 gpm. Pumps will operate against heads to 430 ft. **Food Machinery and Chemical Corp.**, Peerless Pump Div., 301 West Avenue 26, Los Angeles 31, Calif.

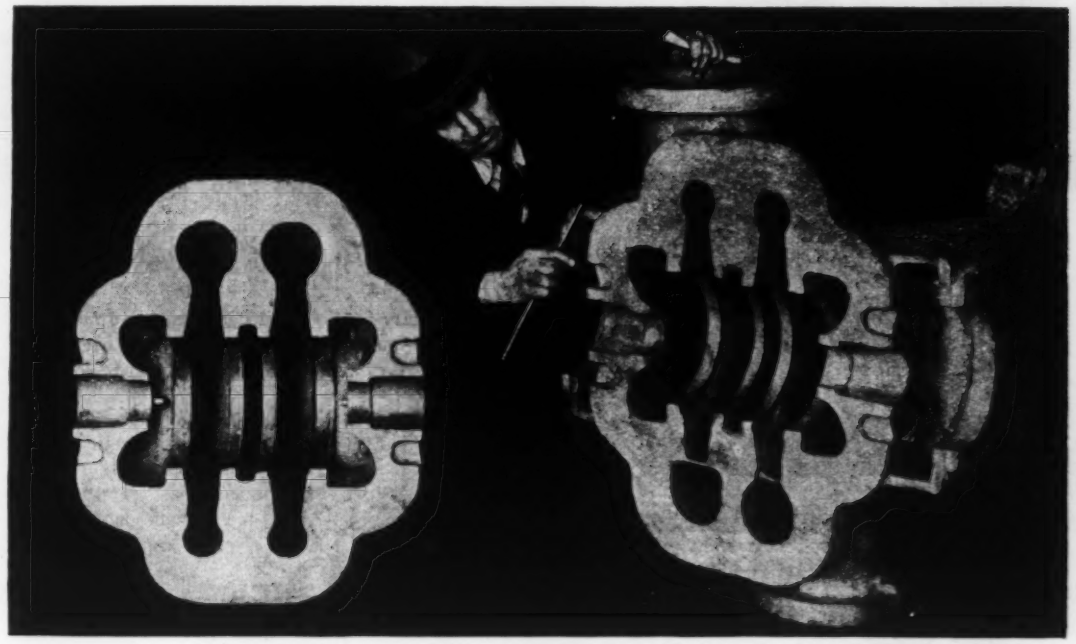
Circle 472 on page 19

Check Valve

in micro sizes

Micro check valves are available in three basic designs in standard AN and MS fittings. Units are aluminum, stainless steel, and titanium in a range of small sizes from # 4 to # 32. Pressure range is 0 to 5000 psi, temperature range is −65 F to +275 F. Seat and





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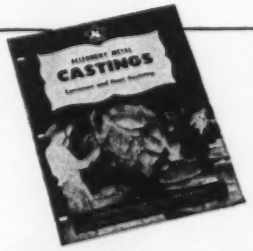

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For your assurance, there's a long record of years of successfully answering difficult service conditions with sound, clean-grained AL Stainless Steel castings—free from defects, easy to machine and dependable in supply. ● Let us quote on *your* stainless casting requirements. *Allegheny Ludlum Steel Corporation, Henry W. Oliver Building, Pittsburgh 22, Pennsylvania.*

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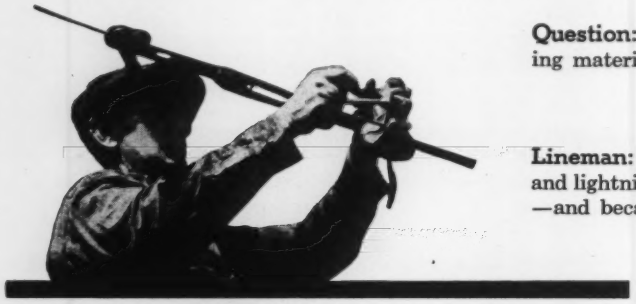
AL STAINLESS STEEL

QUICK QUIZ on a versatile material that's loaded with ideas



Question: "I'm thinking of a unique, low-cost engineering material. What is it?"

Lineman: "Is it used in circuit breakers (arc chutes) and lightning arrestors because of its high arc resistance —and because it is easy to machine or form?"

Athlete: "Is it easily formed and deep drawn to make safe, shockproof helmet crowns, and other lightweight protective guards that withstand repeated hard blows without damage?"

Weldor: "Do you find it in weldors' helmets and electrode holders because it's light yet tough; won't crack, dent or break? Does it have high insulating values even in thin sections?"

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WILMINGTON 99, DELAWARE
In Canada: **National Fibre Company of Canada, Ltd., Toronto 3, Ontario**

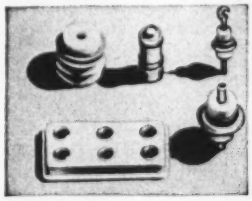
sealing member are precision made for perfect sealing. Valves conform to Mil-V-5524A specification. **Integral Corp.**, Dept. 0-7, 100 Frank Rd., Hicksville, L. I., N. Y.

Circle 473 on page 19

Metal-Ceramic Seals

have high temperature resistance

AlSiMag alumina ceramic seals offer high strength at higher temperatures and frequencies. Ceramics have close dimensional



tolerances, very low dielectric loss, excellent insulation resistance and high softening temperature. Metal to ceramic bond is permanent. Seals are made to customer's specifications. **American Lava Corp.**, Cherokee Blvd. & Mfgrs. Rd., Chattanooga 5, Tenn.

Circle 474 on page 19

Vinyl Sleeving

for 105-C service

Vinyl-coated, glass-fiber sleeving, known as BH Vinyl-Sil 105, has UL approval for 105-C operating temperature. Supporting braid prevents total cut-through and reduces danger of shorting out. Sleeving is available in yellow or green, in all NEMA standard sizes, and in various lengths. Applications are for electrical and electronic equipment where insulation is bent over sharp edges which could cause failure. **Bentley, Harris Mfg. Co.**, Conshohocken, Pa.

Circle 475 on page 19

Freon Coupling

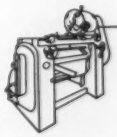
is leak-proof under severe conditions

Self-sealing coupling, designated the series 5400, is designed for easy bulkhead installation in lines of Freon 12 and 22 systems. A

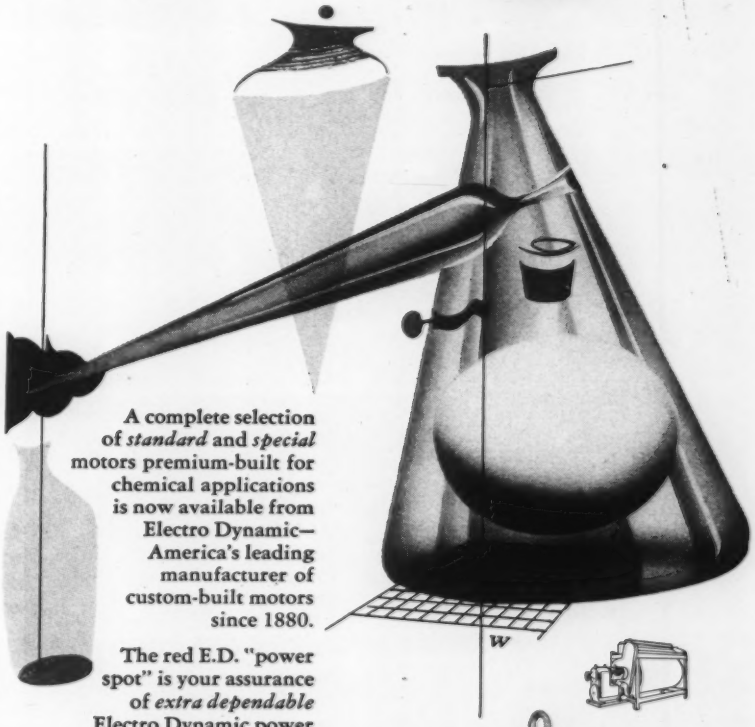
(*Continued on Page* 184)

a better kind of power

for the chemical industry

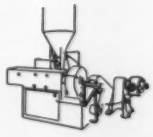


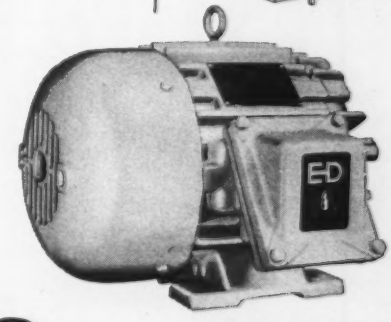
The mark of an Extra Dependable machine



A complete selection of *standard* and *special* motors premium-built for chemical applications is now available from Electro Dynamic—America's leading manufacturer of custom-built motors since 1880.

The red E.D. "power spot" is your assurance of *extra dependable* Electro Dynamic power —75 years in the making—yours today *at no extra cost!*





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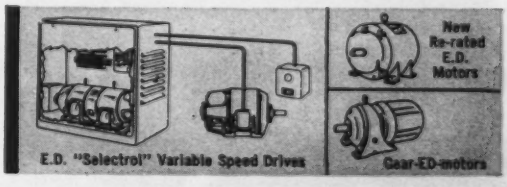
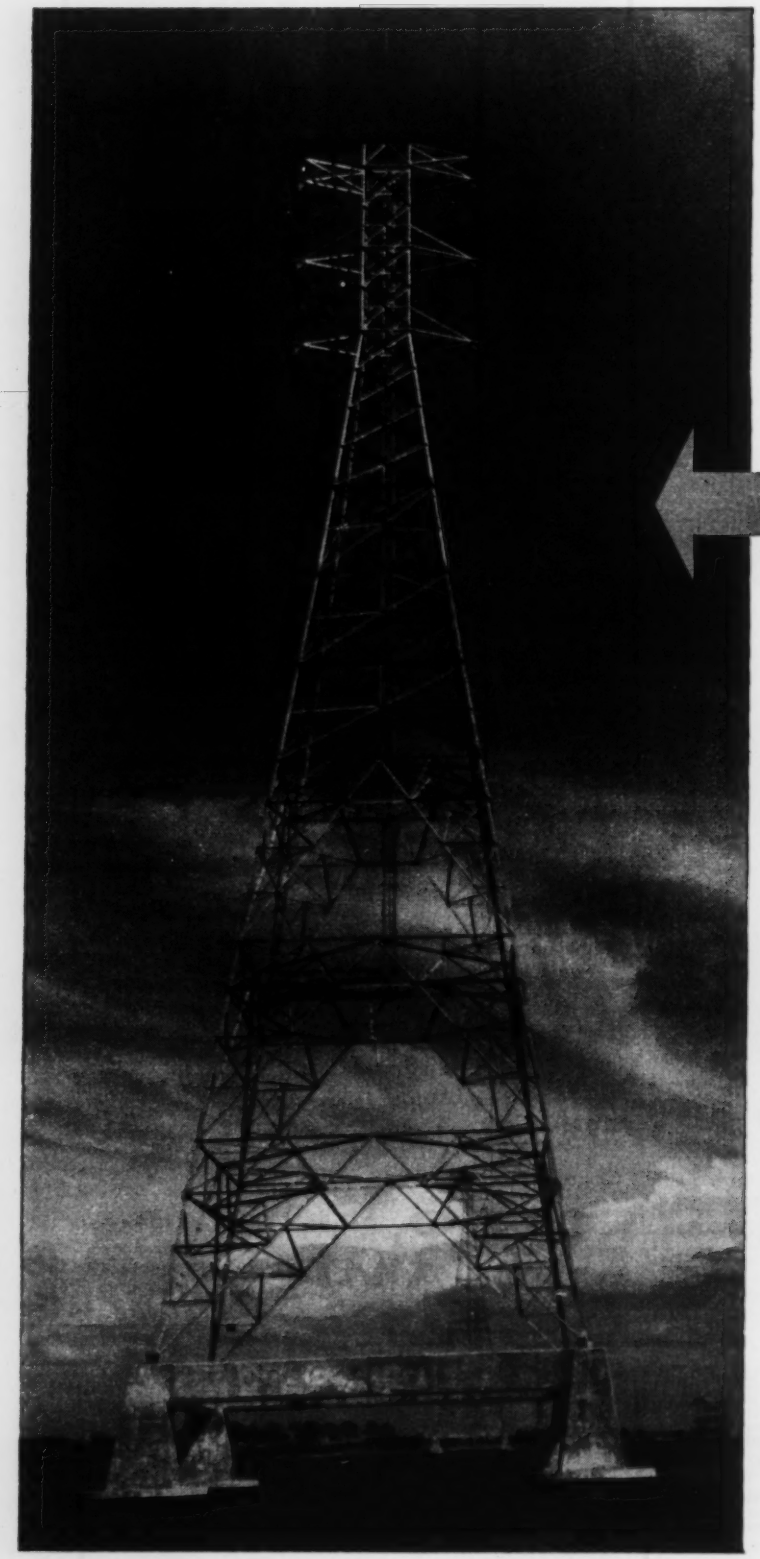
Electro Dynamic division of General Dynamics Corporation Bayonne, New Jersey



Circle 598 on page 19

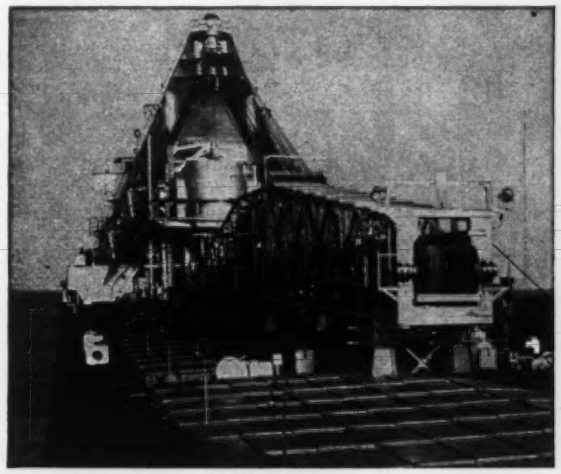
You can make it better



ERECTION COSTS REDUCED $7,200 by using USS MAN-TEN Steel rather than carbon steel in the legs of four 198 ft. transmission towers that carry power lines across Old Tampa Bay, Florida. Six tons of weight saved by MAN-TEN Steel in the East Bank tower saved $1,200 in erection cost. The 6½ tons saved in each of the three towers erected in the Bay saved $6,000 more. The total of 26 tons of steel saved by using MAN-TEN Steel also reduced the cost of the material used in the towers, even though MAN-TEN Steel costs a little more per lb. (Towers designed and fabricated by American Bridge Division of United States Steel for Florida Power Corporation, St. Petersburg, Fla. Erected by Southeastern Utilities Service Co., Miami, Fla.)

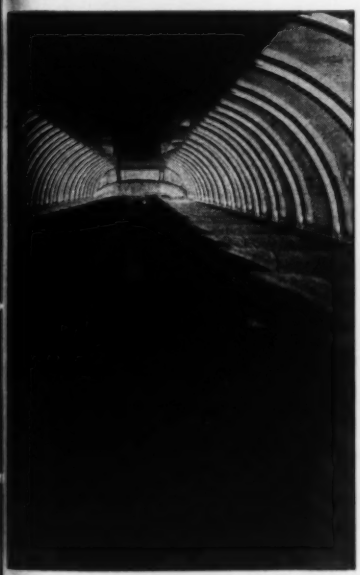
THE SUPERIOR STAMINA and corrosion resistance of USS COR-TEN Steel save power by saving weight, insure minimum maintenance and longer service life in this full-length "dome" lounge car built for the Milwaukee Road by Pullman-Standard Car Manufacturing Company, Chicago, Ill. More than 6,000 modern passenger cars and 190,000 freight cars of all types have been built to date with USS COR-TEN Steel.

with USS High Strength Steels



USED IN THE LOADING BOOM and supporting "A" frame of this self-unloading cargo vessel which can discharge 4,500 tons of limestone per hour, USS TRI-TEN "E" Steel not only materially increases the strength and durability of the structure but saves more than 18,000 lbs. of weight. 50,000 lbs. of TRI-TEN "E" Steel in plate and structural form were used in this application. (Designed by Robins Engineers, Division of Hewitt-Robins, Incorporated, for Manitowoc Shipbuilding, Incorporated.)

WEIGHT WAS REDUCED 10% yet strength-to-weight ratio was increased over former construction by using USS MAN-TEN Steel in the arch boom, "A" frame and tongue of this heavy-duty logging unit. The increased strength provided by MAN-TEN Steel makes it possible to handle log loads of maximum size—the reduced weight ensures greater mobility and maneuverability. Result: more footage, handled faster. (Designed and built by Hyster Company, Portland, Ore.)



IN USS HIGH STRENGTH STEELS, design engineers have at their command three service-tested steels that will permit them to materially increase the efficiency and economy of machinery, equipment and structures at little or no increase in first cost . . . and frequently, at a saving.

All three of these famous "steels that do more" — USS COR-TEN, USS MAN-TEN and USS TRI-TEN — have a 50% higher yield point than ordinary carbon steel. All have better corrosion resistance and offer greater resistance to wear, fatigue and impact. Each, however, has specific superior properties that should be considered in determining its selection.

USS COR-TEN Steel, for example, is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel. USS MAN-TEN Steel is intended for weight reduction by means of greater strength in moderate forming applications, with enhanced resistance to abrasion and atmospheric corrosion. USS TRI-TEN Steel's outstanding characteristics are excellent weldability and resistance to shock at low temperatures.

Used singly or in combination, these steels can advantageously replace carbon steel to increase the strength and durability of vital parts *without* increasing their weight. Or when the use of thinner sections is feasible they can (1) reduce equipment weight without reducing its strength, or (2) increase the size and capacity of equipment without increasing total weight or the power required to move it.

You will find our 174-page *"Design Manual for High Strength Steels"* extremely useful in applying the benefits of these steels to your product. Send for free copy—simply write on your company letterhead to United States Steel Corporation, Room 5528, 525 William Penn Place, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

1933 USS HIGH STRENGTH STEELS 1956
UNITED STATES STEEL
23 YEARS OF PERFORMANCE

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

UNITED STATES STEEL

★ Model 1AM ★ Model 2AM ★ Model 4AM ★ Model 6AM ★ Model 8AM

GAST rotary vane AIR MOTORS

offer explosion-proof, variable-speed power that's surprisingly compact!

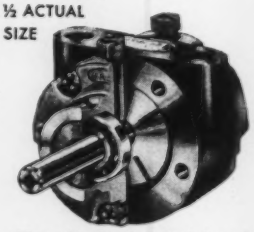
Here's the complete 5-star line of Gast rotary-vane Air Motors . . . offering ten unique advantages on products or applications located near a compressed air source:

1. Explosion-proof power in explosive or inflammable atmospheres. No sparks, no danger!
2. Low initial cost compared to other motors.
3. Variable in speed with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on 4AM and 8AM.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly compact and light for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

As original equipment, Gast Air Motors are driving pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, thread spooling machines and many other products. Right or left rotation available. Housings available with or without foot on most models.

GAST MANUFACTURING CORP.,
P. O. Box 117-P, Benton Harbor, Mich.

MODEL 1 AM
½ ACTUAL SIZE



Note the simple principle and trouble-free construction.

PERFORMANCE TABLE

Model No.	R.P.M.	HORSE POWER at 60 P.S.I.	HORSE POWER at 90 P.S.I.	Wt. Lbs.
1 AM	2,000 5,000	0.11 0.21	0.13 0.30	1½
2 AM	1,000 2,000	0.22 0.40	0.35 0.57	5¼
4 AM	1,000 2,000	0.48 0.78	0.73 1.10	7½
6 AM	500 2,000	0.40 1.30	0.65 2.00	18
8 AM	500 1,500	1.00 2.30	1.45 3.80	25

For complete performance data, write for Bulletins! Specify models that interest you.

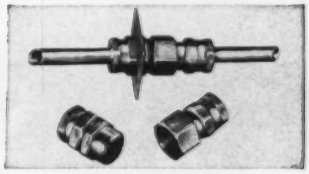
Original Equipment Manufacturers for Over 25 Years

GAST ROTARY
• AIR MOTORS TO 4 H.P.
• COMPRESSORS TO 30 P.S.I.
• VACUUM PUMPS TO 28 IN.
SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Circle 600 on page 19

New Parts

(*Continued from Page* 181)



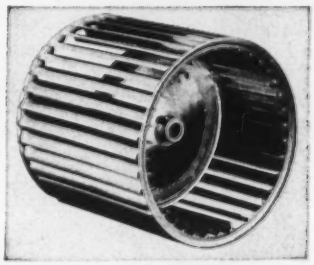
jam nut locks one section of coupling to bulkhead. Adapters of coupling are recessed for brazing to copper tubing. Application is primarily for air conditioning units which are precharged with Freon at factory, and must sustain no loss of Freon during shipment and storage. Tube size range is 1/4-in. through 1½ in. OD. **Aeroquip Corp.**, Jackson, Mich.

Circle 476 on page 19

Blower Wheel

has locked-in center disk

Blower wheel has center disk dovetailed under compression into encircling blades, which tighten at high rotational speeds, thus eliminating looseness, blade rattling, and blade-angle warp. Operation of rotor at higher speeds than conventional wheels is possible. Rotor



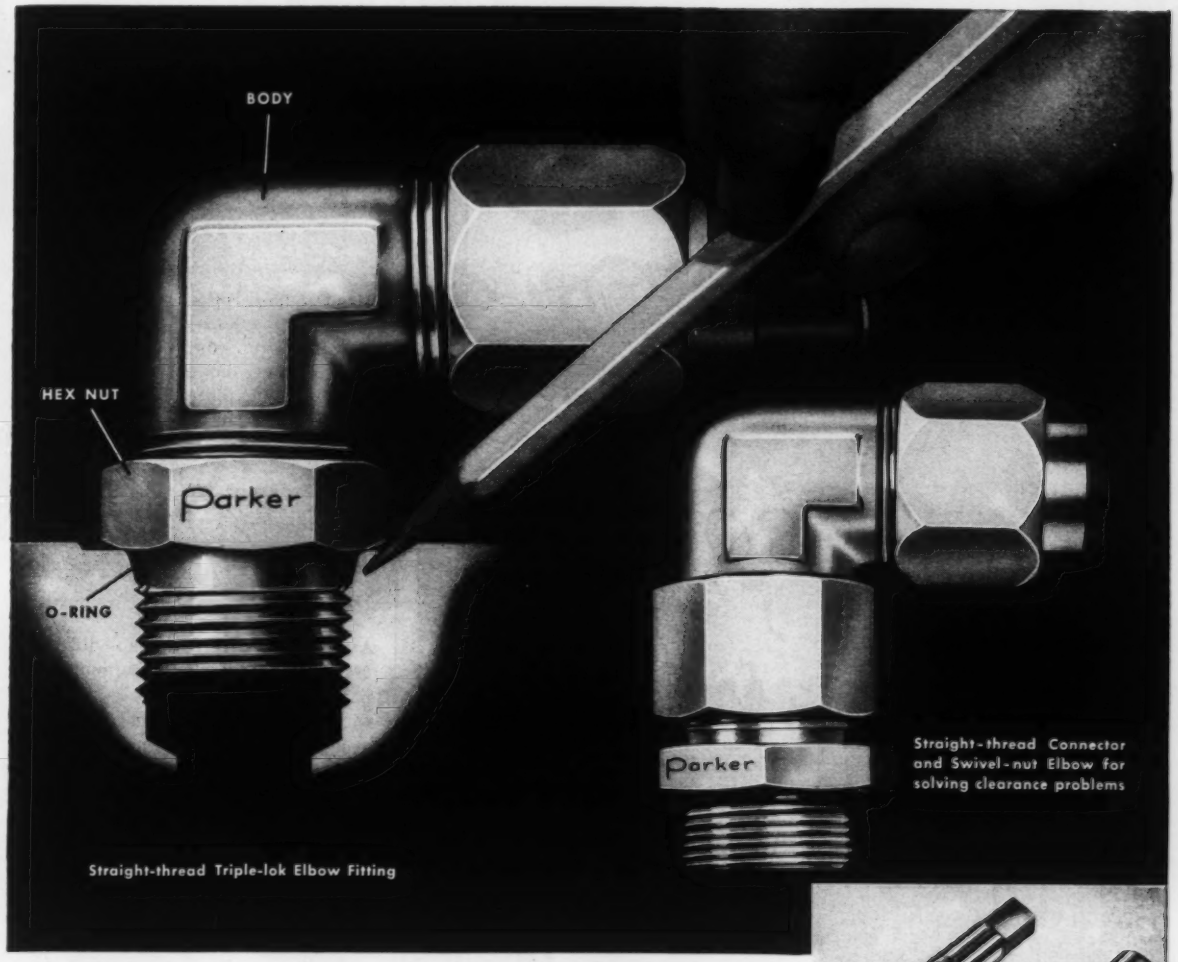
is available in six sizes: 9½ in. diam by 7⅛ and 9½ in. widths; 10⅝ in. diam by 8 and 10⅝ in. widths; and 12⅝ in. diam by 9½ and 12⅝ in. widths. **Torrington Mfg. Co.**, Air Impeller Div., Torrington, Conn.

Circle 477 on page 19

Electromagnetic Clutches

are miniature size.

Electromagnetic clutches have servo mounting concentric with input gear hub and output shaft. Input hub and output shaft are coupled when clutch is energized, and both are free when de-ener-



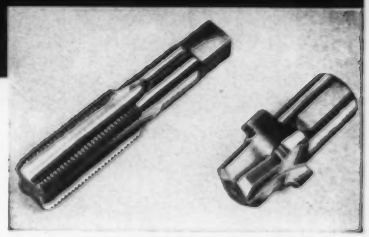
New Parker *straight*-thread fittings solve your leakage problems

Now you can forget about high-pressure hydraulic problems resulting from tapered pipe threads. Forget about leakage . . . about the danger of cracking or distorting valve bodies by over-tightening the fittings . . . about damaged threads from over-tightening to obtain proper positioning. Forget about messy pipe "dope".

You can eliminate all of these problems by using new Parker *straight*-thread fittings with positive O-ring seals. (See illustration above.)

Parker *straight*-thread fittings are now being supplied in response to the growing demand for this new type of leakproof, trouble-free connection. They are shorter and have smaller hexes than the AN fitting for the old AND 10050 boss. *Straight* threads are available on *Triple-lok* (the industrial standard flare tube fitting) and on *Ferulok* (flareless fitting for heavy steel tubing).

This is another example of Parker's pioneering leadership in the field of hydraulic fittings. Mail the coupon today for complete information.



Precision thread-tapping and counterboring tools for making accurate *straight*-thread boss (to receive these new Parker *straight*-thread fittings) are now available with machining drawings from Parker.

Parker

Hydraulic and fluid system components

TUBE AND HOSE FITTINGS DIVISION
Section 412-N

The Parker Appliance Company
17325 Euclid Avenue
Cleveland 12, Ohio

Send Catalog 4301.

Name_____

Company_____

Address_____

City_____ State_____

Circle 601 on page 19

One source for component parts really pays off... coordinated shipments, the same high quality standards, one responsibility are just a few of the many advantages. H-P-M is the source for a complete line of pumps, power units, valves, cylinders and system accessories. H-P-M's experience background in the design and building of hydraulic systems can be a real help when needed. Write today for a complete catalog. Ask for Bulletin 1101. Make H-P-M your standard for savings.

HYDRAULIC POWER DIVISION
THE HYDRAULIC PRESS MFG. CO.
Mount Gilead, Ohio, U.S.A.
A DIVISION OF KOEHRING COMPANY

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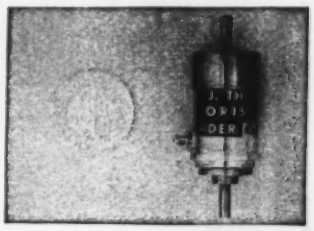
Circle 602 on page 19

New Parts



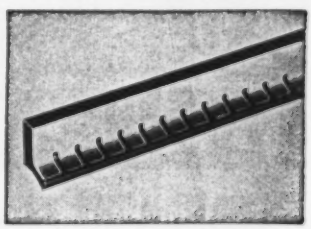
gized. Controlled torque output under vibration meets Mil-E-5272A. Units operate on dc voltage. Three models range in size from 0.59-in. diam by 0.93-in. long to 1.37 in. diam by 1.765 in. long, and transmit 4 to 60 oz-in. of torque. **A. J. Thompson, Inc.**, Box 812, Florissant, Mo.

Circle 478 on page 19

Way Wipers

of synthetic rubber

Available with three different types of metal reinforcements and one unreinforced type, Sirvene way wipers are 22 in. long, and are cut to required length. Wiper cleans metal ways of dirt, chips



abrasive dust, and cutting compounds, leaving only fine film of oil, thus preventing scoring and promoting longer life in precision ways. **Chicago Rawhide Mfg. Co.**, 1267 Elston Ave., Chicago 22, Ill.

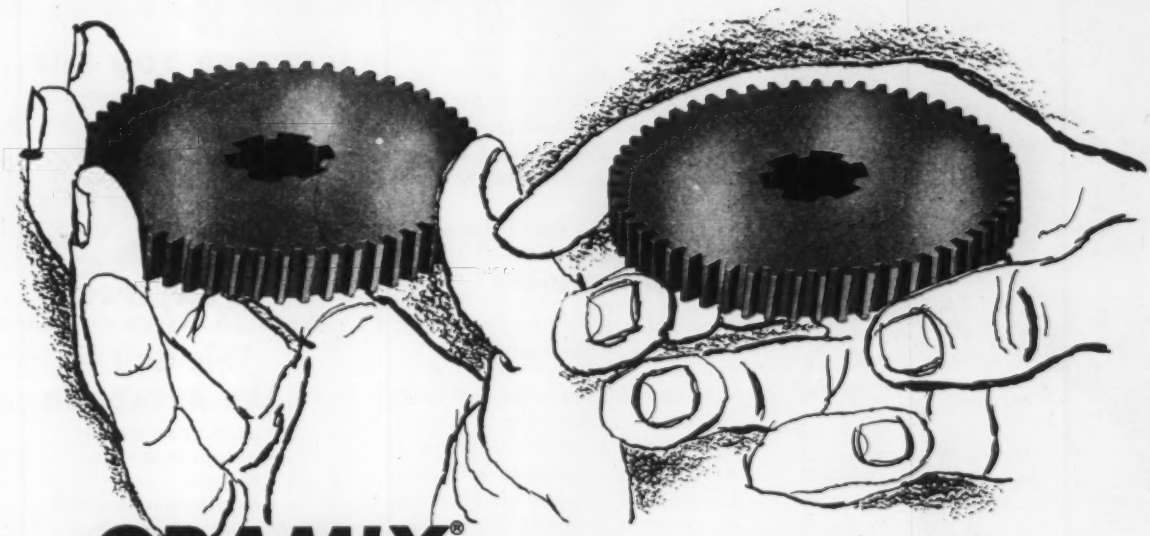
Circle 479 on page 19

Fan Motor

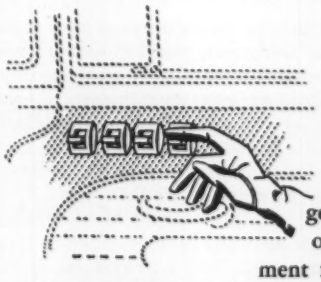
for air conditioners is 4 1/4 in. long

Permanent - split - capacitor fan motor is available in ratings up to 1/6 hp. Unit is prelubricated.

which helical gear costs 80% less?



the GRAMIX® sintered metal helical gear performs better than a forged and hobbed aluminum part for just 1/5 the cost!



By replacing forged aluminum gears with sintered steel GRAMIX helical gears, a manufacturer of automotive equipment found that he could realize an 80% saving and get greater dependability. The gear is a component of an automatic window raising and lowering mechanism currently being used by four different automobile manufacturers. The helical teeth are formed in the compacting dies, and, after sintering, the GRAMIX gear is ready for assembly into the power window unit . . . there is no need for costly machining or time-consuming finishing operations like the hobbed aluminum gear used previously. In spite of the astonishing savings, these GRAMIX gears have proven to be even better than the former forged gear from a standpoint of toughness and wearability.

114

GRAMIX metallurgists can provide the exact alloy for your design specifications. GRAMIX parts may be oil-impregnated for self-lubrication. They seldom need machining, and will often outlast similar machined parts. Complex shapes can be produced to tolerances as close as .0005". Whatever your requirements may be, it will pay you to investigate GRAMIX.

Do you have our big detailed GRAMIX catalog? . . . write today for your copy.

THE UNITED STATES GRAPHITE COMPANY

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Let's put our heads together

Research has produced "KARAK". Let's put our heads together and see if we have something for you.

Pictured precision seals are illustrations of successful "KARAK" applications.

Carbon graphite seals—stationary or rotating—solid or sectional. Non contaminating and inert in most acids and alkalis. KARAK will seal water, steam, aircraft fuel, gases, grease and many less common materials.

Adaptable grades of KARAK meet an impressive array of physical and chemical requirements. Extreme resistance to thermal shock, withstands heat to 700°F in air, wide hardness range, transverse strength to 14000 psi are all variable properties of KARAK.

Would you like to know more about KARAK?

design with KARAK in mind

THE OHIO CARBON COMPANY

12508 BEREA RD CLEVELAND 11 OHIO

Circle 604 on page 19

New Parts

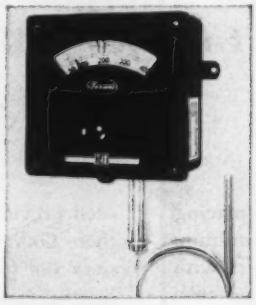
equipped with quick-disconnect terminals, and is protected from humidity and salt air by protective varnish on the stator and shell assembly. Output is 100 w, rpm range is 1040 to 1150. Motors are 4.25 in. long, 5 to 6 in. diam. Applications are primarily for room and console air conditioners. **General Electric Co.**, General Purpose Motor Dept., 1 River Rd., Schenectady 5, N. Y.

Circle 480 on page 19

Temperature Controller

has wide range of interchangeable components

Indicating temperature controller, designated Series 541 bulb-and-capillary type, offers accuracy of ±2 F, and is available with wide range of interchangeable elements, allowing unit to be tailored to application. Four control mechanisms, six temperature ranges, four control switches, three bulb



diameters, and two capillary lengths are offered. The operating temperature of the control switch (or switches) is adjusted with external knob (or knobs) on controller housing. Bulb temperature is indicated by pointer on lower half of dial face and is readily compared with control setting pointer on upper half. Controller is operable at ambient temperatures of 50 to 150 F. **Fenwal Inc.**, Ashland, Mass.

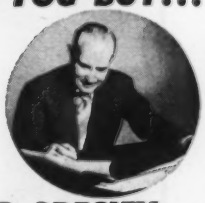
Circle 481 on page 19

Trimmer Potentiometer

for printed circuits

Miniature wire-wound trimmer potentiometer for printed circuits has resistances from 100 to 40,000 ohms, resolutions ranging from 0.3

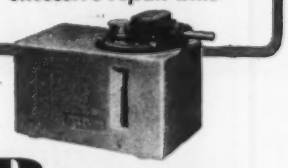
WHETHER YOU BUY...



OR SPECIFY...

This Unit Is The Answer To

- production waste
- design problems
- fire risk
- excessive repair bills



BIJUR

AUTOMATIC LUBRICATION

Automatic lubrication is one thing that designers, plant engineers and production men insist on these days—for their own machinery . . . and the equipment they manufacture. And careful purchasers make sure the automatic lubrication systems they buy are *Bijur Systems.*

For nothing protects like Bijur. Bijur Systems save production time and repair bills . . . reduce downtime and fire risk . . . lengthen machine life . . . and eliminate product spoilage due to over-lubrication. Bearings are never thirsty for oil, never flooded.

That's why it's just good business to have a custom-engineered Bijur System on the equipment you own, and *design* one into the equipment you manufacture. Installation is easy, cost is minimal, savings are substantial. Write today for *all* the facts about Bijur Systems!

P-3

BIJUR LUBRICATING CORPORATION
Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

Circle 605 on page 19

The Best

are the easiest

to get

mean faster deliveries from stock!

FOOTE BROS.
LINE-O-POWER SPEED REDUCERS

Standardized interchangeable gearing – by Foote Bros. – lets you specify and get the particular reducer you want, in the quantities you need, direct from stock! Duti-Rated Lifetime Gearing in a complete range of interchangeable sizes, ratios and capacities are stocked and ready for assembly. Capacities range up to 200 H. P., ratios to over 2700 to 1. Standard foot and flange type cast housings are stocked, too, for straight or right angle drives. The drives you want are assembled from stock components and shipped as soon as your order is received. For a complete index to the almost endless variety of Line-O-Power reducers immediately available, write for your copy of the Line-O-Power catalog today. See for yourself how you can get more for your drive dollar . . . faster!

This trademark stands for the finest industrial gearing made!

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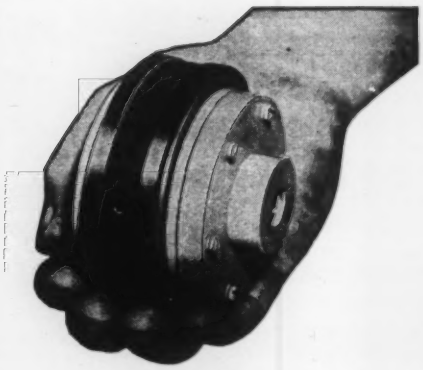
Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

4545 South Western Boulevard, Department O, Chicago 9, Illinois

Circle 606 on page 19



Be Sure with a

Matched-to-the-Machine

STEARNS MAGNETIC CLUTCH

On many machines, a standard magnetic clutch does the job.

On others, however, a special custom-made unit is needed for the most profitable results.

In either case, you're right with Stearns — because this pioneer in magnetic equipment builds both.

Here are important reasons why Stearns magnetic clutches provide positive dependable control on such a wide variety of applications.

- *Torque range from .4 to 30,000 lb. ft.*
- *Low inertia — fast, smooth engage and disengage. Split shaft, through shaft, two speed drives, forward and reversing drives — other special applications.*
- *Quiet and cool running. No metal-to-metal contact, no sparking.*
- *Automatic or manual control.*
- *No toggles, yokes, shifters.*
- *Simple adjustment.*

Let Stearns' design and engineering experience work for you. Consult your Sweet's Product Design File or write for bulletin 226-D.

1083

Stearns ELECTRIC CORPORATION

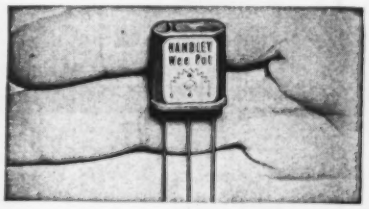
formerly STEARNS MAGNETIC INC.

120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

Circle 607 on page 19

New Parts

per cent to less than 0.1 per cent, and power rating of one watt at 40 C. Metal case can be potted or hermetically sealed, and screw adjustment for wiper position has 40-turn adjustment screw. Adjust-



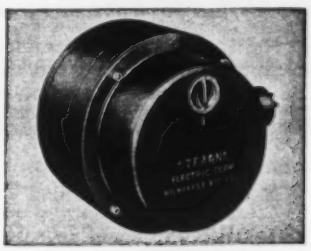
ment is unaffected by severe vibration, shock, or humidity change. Resistance tolerance is 5 per cent, and temperature coefficient is 0.002 per degree C. Unit is 3/4-in. by 3/4-in. by 5/16-in. Weight is 5 grams. **Handley Electronics Inc.**, 14758 Keswick St., Van Nuys, Calif.

Circle 482 on page 19

Magnetic Brake

for dust-explosive atmospheres

Dust - explosion - proof magnetic disk brakes are for use on electric motors in atmospheres containing combustible dust. Offering instant



stop-start and holding ability, Series-70 brakes are available in four models with maximum torque ratings of 10 through 75 lb ft. **Stearns Electric Corp.**, 635 S. 28th St., Milwaukee 46, Wis.

Circle 483 on page 19

Tachometer Generators

for ac and dc are 3 5/16 in. diam.

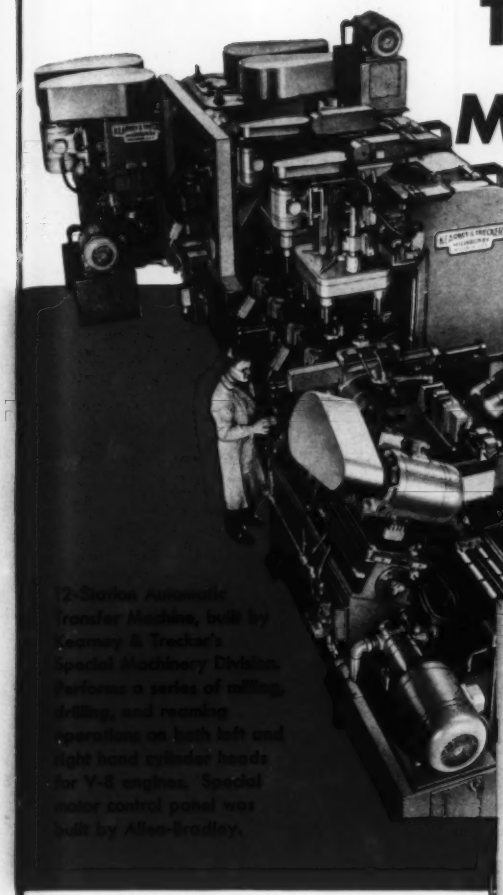
Small diameter ac and dc tachometer generators are totally enclosed and ball bearing equipped. Four-pole ac tachometer has speed range of 400 to 5000 rpm, voltage output of 28 v per 1000 rpm, ±10 per cent. The ac generator is

Circle 608 on page 19→

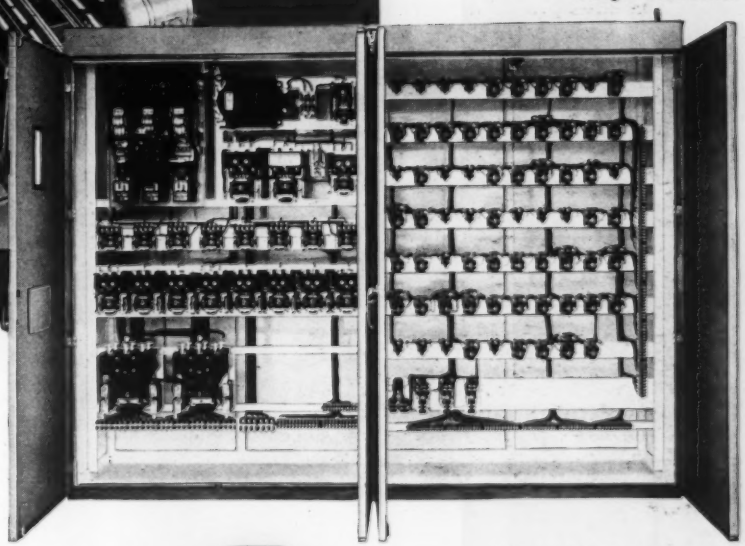
Satisfied Customers

RESULT FROM THE USE OF

Trouble Free Motor Control Panels



12-Station Automatic Transfer Machine, built by Kearney & Trecker's Special Machinery Division. Performs a series of milling, drilling, and reaming operations on both left and right hand cylinder heads for V-8 engines. Special motor control panel was built by Allen-Bradley.



Bulletin 849
Pneumatic Timer

Bulletin 709
Automatic Solenoid Starter

Bulletin 802T
Oiltight Limit Switch

Bulletin 800T
Oiltight Push Button

You get two definite advantages when you let Allen-Bradley furnish your special control panels, namely—trouble free, continuous reliability plus ready customer acceptance.

Allen-Bradley control panels are built from standard components whose reliability and maintenance free operation have been proven in many years of service. Their simple design is your guarantee of millions of trouble free operations. The familiar A-B trademark—recognized universally as the sign of QUALITY—is a decided sales asset on your equipment.

Write for your copy of the Allen-Bradley Handy Catalog—the quick and easy reference guide that will help you select individual control units, or components for special control panels.

A-B Quality

ALLEN-BRADLEY

MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

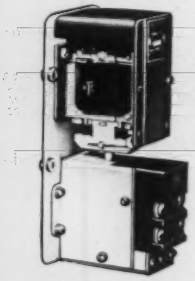
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

7-56-R

Bulletin 702
Solenoid Contactor

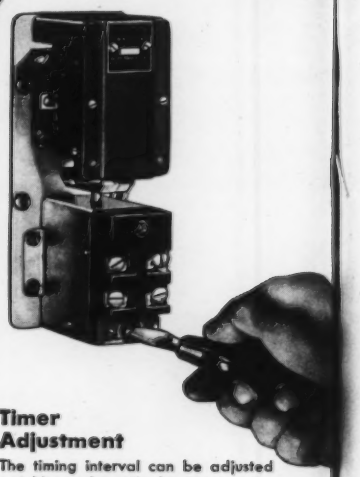
Bulletin 700
Solenoid Relay

TIMING RELAYS!



Bulletin 849 "On-Delay" timer. By inverting solenoid, timer is converted to "Off-Delay" operation.

Installing instantaneously operated contact block with one N.O. and one N.C. contact



Timer Adjustment

The timing interval can be adjusted quickly and easily by turning the adjusting screw.

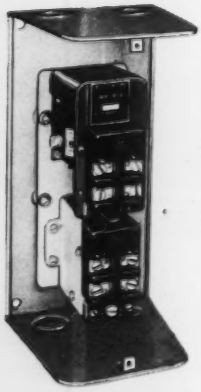
Tell Us About YOUR TIMER NEEDS . . . Allen-Bradley Has the RIGHT ANSWER!

Here is a line of pneumatic timers that can be adjusted for a consistent time delay of 1/6 second up to 3 minutes. Air, drawn into the timer through a needle valve, is freed from dirt and dust down to submicroscopic size by a high efficiency glass fiber paper filter. Thus the time settings are accurately maintained over long periods. These timers can be expected to operate reliably under conditions of severe atmospheric contamination.

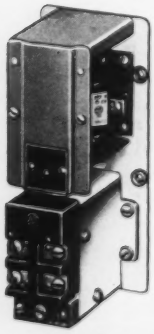
An outstanding feature of these timers is the wide variety of types available, and the modifications which can be made in the field, such as adding one or two instantaneously operated auxiliary contacts. Also, it is easy to change an "On-Delay" timer to the "Off-Delay" operation, or vice versa—by simply inverting the operating solenoid. The "On-Delay" timer provides the time delay *after* the magnetic operating COIL IS ENERGIZED; the "Off-Delay" timer provides the time delay *after* the operating COIL IS DE-ENERGIZED.

The Bulletin 849 timer has one normally open and one normally closed contact. As usual, the Allen-Bradley double break, silver alloy contacts are maintenance free. Auxiliary contacts can be mounted as shown below.

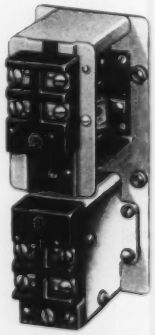
A few typical Bulletin 849 Pneumatic Timer combinations



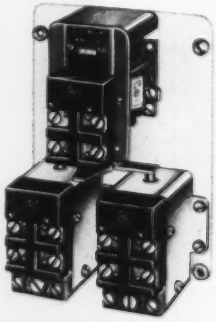
Bulletin 849 timer with one N.O. and one N.C. auxiliary contact.



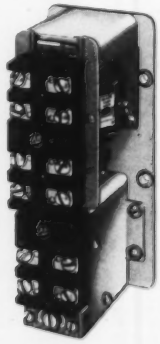
Bulletin 849 "Off-Delay" pneumatic timer with time delay *after* the coil is de-energized.



Bulletin 849 "Off-Delay" pneumatic timer with one N.O. and one N.C. auxiliary contact.



Bulletin 849 "On-Delay" pneumatic timer with two adjustable timing units.



Bulletin 849 pneumatic timer with two N.O. and two N.C. auxiliary contacts.

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.

ALLEN-BRADLEY

PNEUMATIC TIMERS

In Canada—
Allen-Bradley Canada Ltd.
Galt, Ont.

7-56-MR

available with base or flange mountings, is 6 in. long, and weighs less than 4 lb. The dc tachometer generator has low shaft inertia (1.4 lb in²) and 1.5 per cent ripple. Tachometer sup-

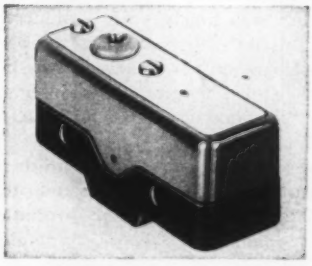
plies sufficient power to operate one instrument and one recorder. Speed range is 100 to 5000 rpm. Tachometer is 7.47 in. long, weighs 6.5 lbs; units are 3 5/16 in. diam. **General Electric Co.**, Specialty Component Motor Dept., 1 River Rd., Schenectady 5, N. Y.

Circle 484 on page 19

Snap-Action Switch

is sealed against moisture and dust

New series 2HB switch is sealed against moisture, dust, or corrosive atmosphere by silicone boot around the operating pin. Switch



operates at 20 amps 125, 250, and 480 v ac, 0.25 amp 250 v dc, and 0.50 amp 125 v dc. **W. L. Maxson Corp.**, Unimax Switch Div., Ives Rd., Wallingford, Conn.

Circle 485 on page 19

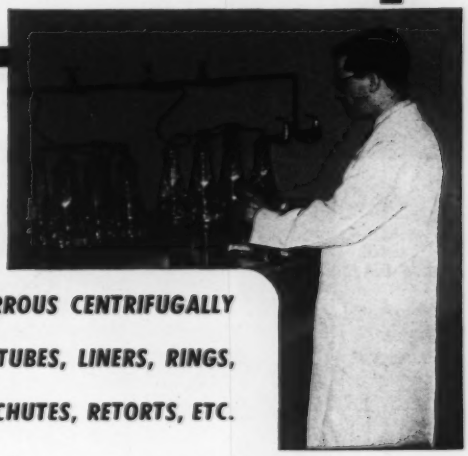
Instrument Cases

in six sizes are drawn from aluminum

Inexpensive drawn aluminum instrument cases are available in six different sizes and two styles. Cases have high-precision, seamless construction with walls held

(*continued on Page* 196)

To Rely on SANDUSKY Is to Rely on Research



CHIEF SANDUSKY

FERROUS AND NON-FERROUS CENTRIFUGALLY CAST ROLLS, SLEEVES, TUBES, LINERS, RINGS, BUSHINGS, BEARINGS, CHUTES, RETORTS, ETC.

There's a great deal more to a centrifugal casting than the finished product itself. It starts in the early stages of development and planning when Chief Sandusky technicians, through research and test experience, are able to specify valuable procedures that will save production expense and man-hours in your operation.

Add to this research the right materials and consistent control and the result is a ferrous or non-ferrous casting which will do its specific job while resisting heat, abrasion, and corrosion as required. An additional service is machining facilities for turning, boring, and drilling.

Rely on Chief Sandusky as an organization of specialists with the answers to your problems with the finest of centrifugal castings.

C. M. Lovsted & Co., Seattle, Wash. • Tynes Bros., Birmingham Ala. • Cordes Bros., San Francisco and Wilmington, Calif.

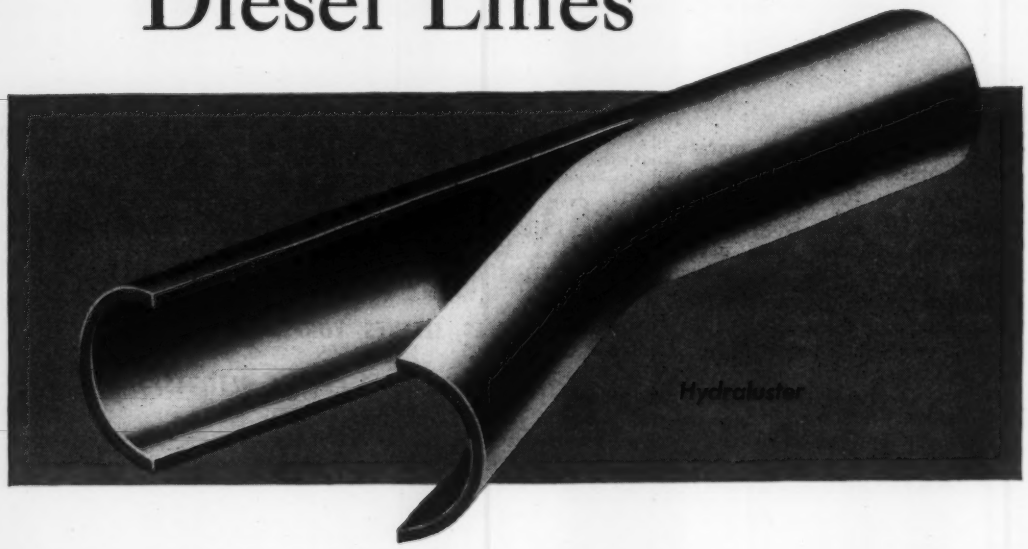
Chief SANDUSKY CENTRIFUGAL CASTINGS

FERROUS AND NON-FERROUS

SANDUSKY FOUNDRY AND MACHINE CO., Sandusky, Ohio

Circle 609 on page 19

A New Material for Hydraulic and Diesel Lines



T. L. PARKER Vice President
Columbia Steel and Shafting Co.

Interior scaling and flow resistance—magnified by the introduction of the newer, high speed hydraulic fluids—point up a problem that is not entirely new to designers and engineers in the hydraulic and diesel fields. Oxidation and scale adhering to tubing walls can restrict flow in fluid systems, causing pressure changes and forcing the system to function at a substandard rate of efficiency. This same scale, loose and circulating, of course causes additional damage and premature deterioration of valves and pumps. The introduction of any other type of foreign matter or dirt, during or after manufacture, would have the same general effect.

A new tubing, now available in commercial quantities, is providing a logical solution to the problem. Marketed under the name of Summerill HYDRALUSTER, it has an exceptionally smooth, bright and *clean surface on both interior and exterior walls.* Produced by an annealing process that regulates the cooling cycle as meticulously as the heating phase, Hydraluster is highly resistant to oxidation, and the smooth wall finish is not conducive to dirt adherence. Initially clean, the tubing is shipped fully protected by special preservatives, and it can be provided in individually capped lengths. The preservatives are easily removed with good grades of commercial solvent.

An interesting by-product of the silver-bright finish is the sales appeal it adds to OEM equipment. Hydraluster has the inherent strength and exceptionally fine working properties of steel, and is available at standard hydraulic tubing prices.

SAMPLES and SPECIFICATIONS: While supplies last, we'll gladly send you a sample of HYDRALUSTER. Your name, on company stationery, will bring specifications, descriptive literature and the sample by return mail.

Summerill

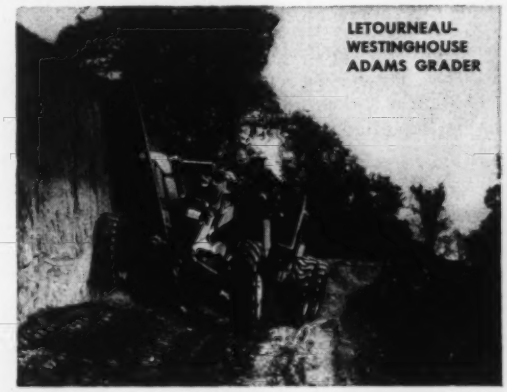
Tubing Company Division-Columbia Steel & Shafting Co.

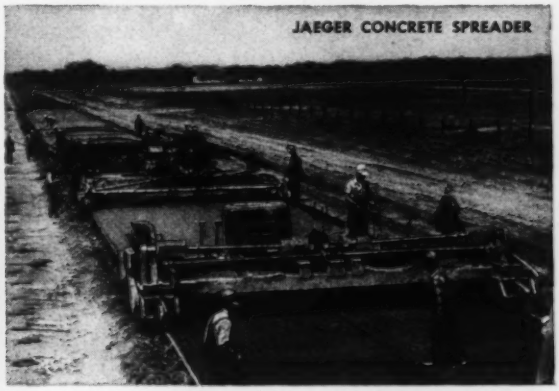
PITTSBURGH 30, PA. DEPT. NO. 1-12

District Offices: Buffalo • Chattanooga • Cleveland • Dayton • Hartford • Philadelphia • Pittsburgh • Milwaukee • Chicago

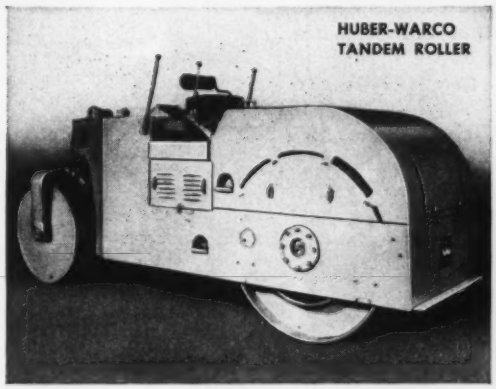
Circle 610 on page 19

Designers of the latest types of road





building and construction machines enjoy



maximum cooperation when they specify

BLOOD BROTHERS UNIVERSAL JOINTS

Supplier-engineering cooperation can often save time when you're designing road building and construction equipment.

At Blood Brothers, a complete staff of engineers is ready to work closely with you. They will gladly assist in selecting standard universal joints and drive lines—or advise on special problems.

As one customer wrote: *"We are seldom able to obtain the prompt and pleasant attention which you have given us in developing these . . . joints".*

Try it for yourself—Write or call Blood Brothers' engineers for suggestions!

BLOOD BROTHERS MACHINE DIVISION

ROCKWELL SPRING AND AXLE COMPANY

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Circle 611 on page 19

FOR LARGE OIL SEALS
IN SMALL QUANTITIES
AT THE LOWEST COST SEE

Universal

Universal's unique manufacturing method which eliminates tooling charges for unusually large diameter oil seals is ideal for experimental and small quantity orders.

Precision-built to give long, efficient, trouble-free service—all Universal Oil Seals specially engineered for floatability, self-alignment and automatic take-up.

Oil seals for every purpose!

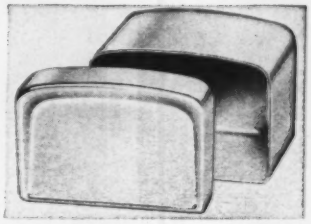
UNIVERSAL
OIL SEAL CO.
P.O. BOX 74
PONTIAC, MICH.

Circle 612 on page 19

New Parts

(*continued from Page* 193)

to close tolerances, uniform thickness, and no draft. Walls are smooth, without die-marks. Cases and covers can be modified to



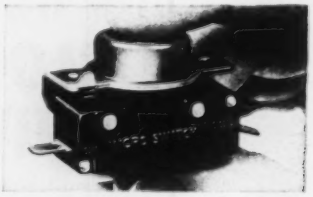
customer specifications with holes, chassis slides, dimpled or rubber feet or other features. **Zero Mfg. Co.,** 1121 Chestnut St., Burbank 9, Calif.

Circle 486 on page 19

Pushbutton Switch

is rated 1 hp at 250 v ac

Snap-action pushbutton switch has high electrical capacity and tamperproof design. Plastic button is keyed to prevent rotation and may be removed to permit engraving. Switch has two No. 6 tapped holes for mounting and spade-type quick-disconnect terminals. Contact ar-



rangement is single-pole double-throw, or single-pole single-throw normally open or normally closed. Rating is 15 amps 125 or 250 v ac, 1 hp 250 v ac, ½ hp 125 v ac. Applications are on computers, vending machines, appliances, and industrial machinery. **Minneapolis-Honeywell Regulator Co.,** Micro Switch Div., Freeport, Ill.

Circle 487 on page 19

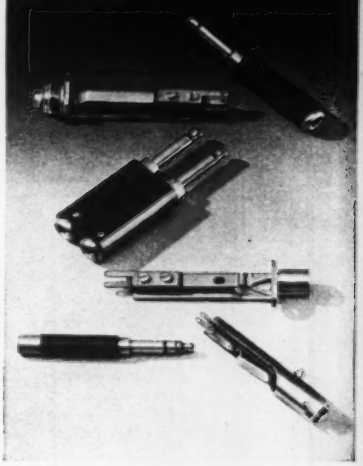
Bearing Seal

for light oil
has long life

Designated Dufelt, oil and bearing seal is a lamination of hycar and felt. Lamination is compressible for tight fit, grease absorbent for low friction, and has excellent re-

SWITCHBOARD-PROVED

Plugs and Jacks



The veteran of telephone equipment suppliers

STROMBERG-CARLSON

offers you the plugs and jacks which survive the torture test of PBX switchboard work!

No matter what programming or patch panel project you have, we doubt if it will subject plugs and jacks to a tougher test than daily use by a telephone switchboard operator.

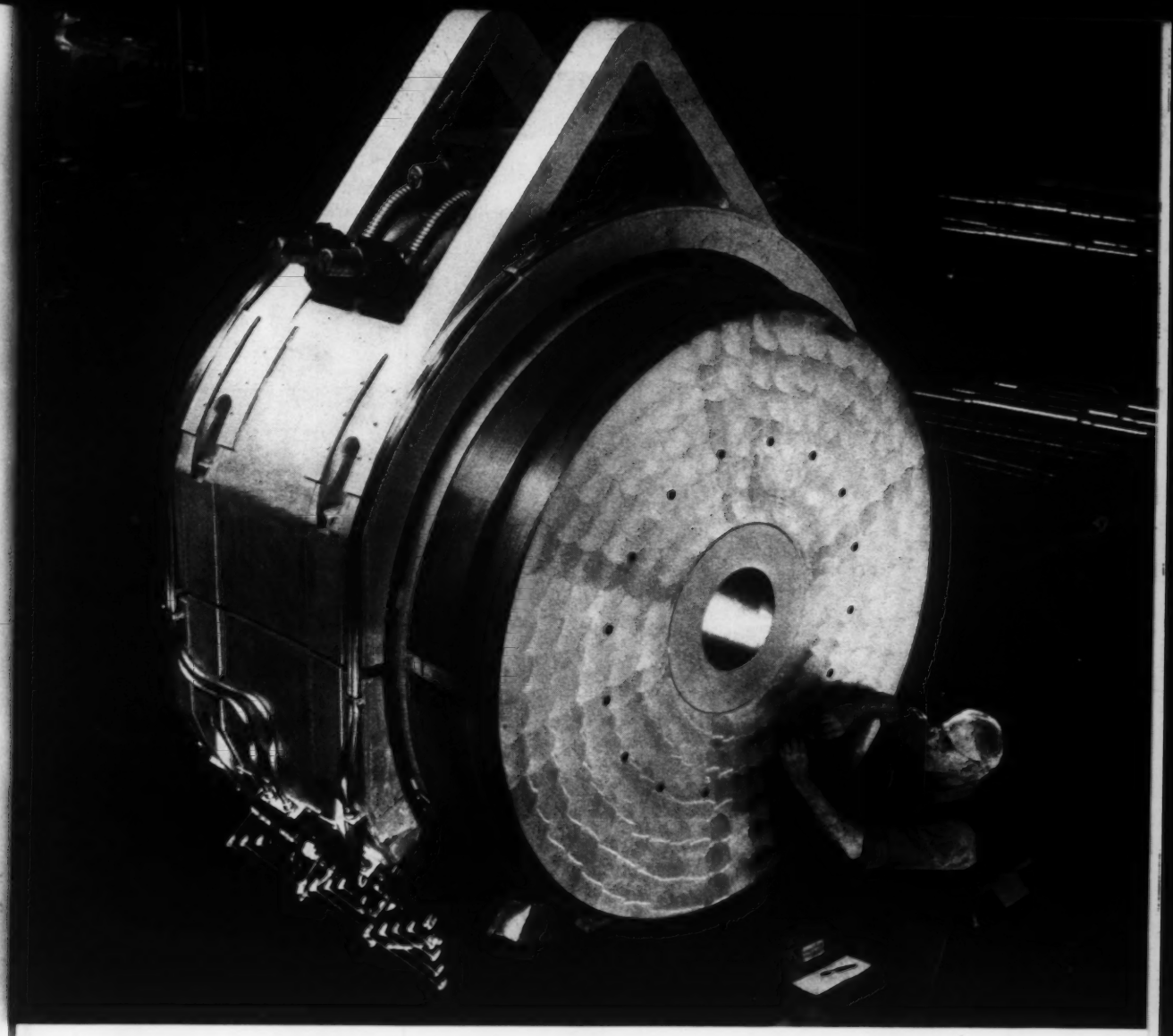
We've been making these products for this purpose for over half a century. Their ruggedness and dependability are attested by service records in telephone companies from coast to coast—and in installations of our armed forces all over the world.

A CATALOG of Plugs and Jacks has just come off the press and will be mailed to you on request. Or write to the address below for a specific need you may have.

S-C STROMBERG-CARLSON

STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS CORPORATION
TELEPHONE INDUSTRIAL SALES
118 CARLSON ROAD, ROCHESTER 3, N. Y.

Circle 613 on page 19



Puzzle: Find the Sleeve

Unless you had a hand in the design or manufacture of this alloy steel billet-container, you might have trouble finding the sleeve we're talking about. Yet part of it is in plain sight.

First of all, we'd better explain a little about the assembly. That outer shell with the lifter loops is heating equipment. Just inside this shell is the billet-container proper, made entirely in the Bethlehem shops. The whole device will be part of one of the 8,000-ton extrusion presses designed and built by Loewy-Hydropress, Division of Baldwin-Lima-Hamilton, for the U.S.A.F. Heavy Press Program.

Now, getting back to the mystery of the sleeve. The container is made up basically of three layers of forgings — a liner (plainly visible), the sleeve, and an outer layer. Because of the perfect shrink fit and the accurate machining, you can't see where the sleeve meets the outer layer. But the sleeve is there, all right, and it runs the full length of the assembly.

Bethlehem has handled many forging and machining jobs that were bigger than this one; the whole assembly weighs only 41 tons. But we've had very few that required more careful workmanship. The container shown here is one of several that Bethlehem was commissioned to do — and all will of course be built to the same high standards.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Circle 614 on page 19

BETHLEHEM STEEL

YOU'LL DO BETTER

WITH **UNITCASTINGS!**

We make no *special* claims to produce miracles with cast steel. Like competitive foundries, problems are similar . . equipment may differ slightly . . it's the *end performance* of the casting that counts!

A little *extra* surveillance in process pays off quality-wise. Customers receive better, cleaner castings . . meeting accepted specifications . . and end up with a lower *finishing* cost. Less scrap . . less re-work . and less lost production time amounts to more than incidentals!

Standard carbon and low alloy steel castings, up to 150,000 psi tensile . . whatever your requirements, specify Unitcastings!

UNITCAST CORPORATION • Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

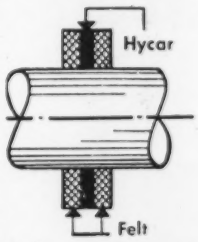
Unitcast

QUALITY STEEL CASTINGS

Circle 615 on page 19

New Parts

sistance to aging and oxidation. Tests in hot and cold oil show no hardening, loss of elasticity, or separation of plys. Durometer hardness of hycar portion averages 70±5 deg. Application is for seal-



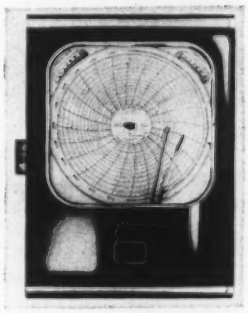
ing of light oil when no head exists. Dufelt may be used under acid conditions down to a pH of 2.5, or in mild alkaline solution at normal temperature. **Felters Co.**, 210 South St., Boston 11, Mass.

Circle 488 on page 19

Pneumatic Controller

offers on-off proportional or derivative control action

Air controller has high stability of control action without loss of sensitivity. Control modes include narrow band (on-off), proportional, reset, derivative, and reset plus



derivative. Unit has wide proportional band width (½ to 400 per cent) with easy shift in width, full zero derivative setting on triple mode controller. Precision linkage allows disassembly and recalibration with only one adjustment. Unit is for measuring and controlling variables such as pressure, vacuum, temperature, flow, and mechanical motion. **Bristol Co.**, Platts Mills, Waterbury 20, Conn.

Circle 489 on page 19

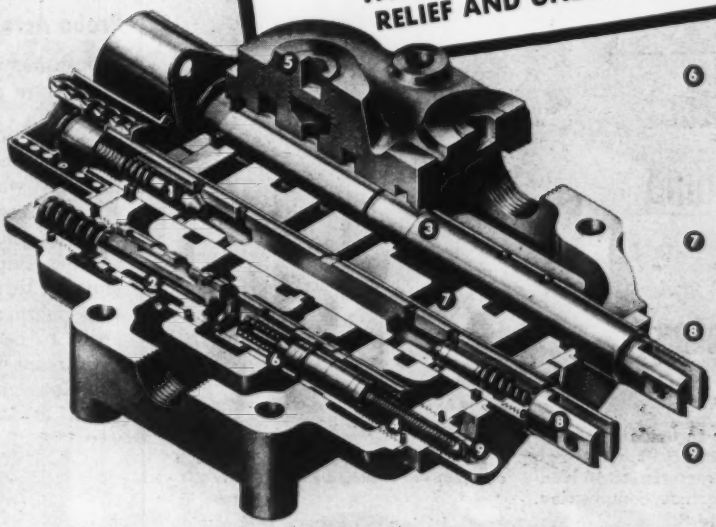
NEW

SERIES V-32 HYDRECO®

HOLLOW-PLUNGER CONTROL VALVE

WITH BUILT-IN PILOT OPERATED RELIEF AND UNLOADING VALVE

1. Built-in check valve eliminates load drop
2. The pilot operated unloading valve bypasses pump discharge
3. All plunger areas hydraulically balanced
4. Pressure setting of relief valve fully adjustable through entire range
5. Simultaneous connection of the pressure port to any number of cylinders
6. Small pressure differential between cracking and full flow with pilot operated relief valve
7. Large oil passage for pilot pressure
8. Valve handles can be located on either end of plunger
9. Alternate location of relief valve adjustment on opposite side



20 GPM • 2000 PSI OPERATING PRESSURE

Here's a new Fluid Power Control Valve with performance features of real importance to builders of Mobile Equipment. The new

HYDRECO®

V-32 SERIES VALVES

have built-in *pilot operated* relief and unloading valve. Now . . . for the first time . . . the operator may adjust relief valve pressures from idling pressure to over 2000 psi *without changing springs.* Now . . . complete unloading of the Pump is effected when working pressure is not required.

Under static loads, the regular valve handle provides direct control of effective pressures . . . a significant feature for control of clamps or other pressure actuated devices. Available with 2 to 6 operating plungers.

Member NFPA

Write *get all the facts on the New Series V-32 HYDRECO Valves.*

KALAMAZOO DIVISION
THE NEW YORK AIR BRAKE COMPANY
9006 E. MICHIGAN • KALAMAZOO • MICH.
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

CONTROLLED FLUID POWER FOR MOBILE EQUIPMENT

MATERIALS HANDLING EQUIPMENT

TRACTOR MOUNTED LOADERS

HYDRAULIC BACKHOES

CONSTRUCTION AND EARTH MOVING MACHINERY

GENERAL MOBILE EQUIPMENT APPLICATIONS

Kalamazoo Division
The New York Air Brake Company
9006-9 East Michigan
Kalamazoo, Michigan

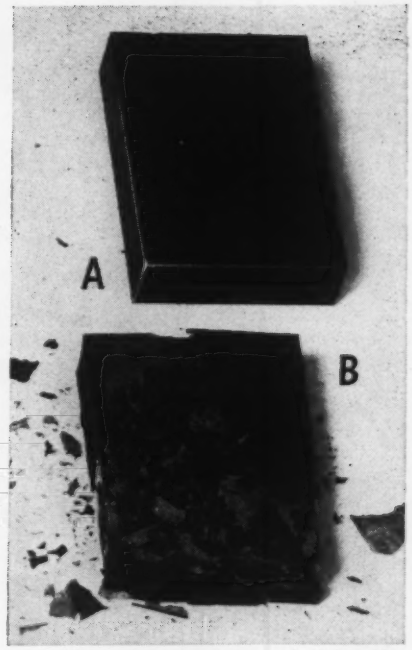
Gentlemen:

I would like more information about the new HYDRECO Series V-32 Valve. Please send me Bulletin 144.

Name_____
Company_____
Address_____
City_____ Zone___ State_____

KENTANIUM*

unharmed at 2000°F while heat-resistant nickel-chrome alloy disintegrates



(Photo A) Kentanium shows only slight oxidation after test and is good for many more hours' exposure at 2000°F. (Photo B) Hard nickel-chromium (35%) alloy is badly oxidized and began to disintegrate during test.

Exceptional resistance to oxidation, combined with great strength at very high temperatures, are characteristics of Kentanium, a titanium carbide composition. Here's proof.

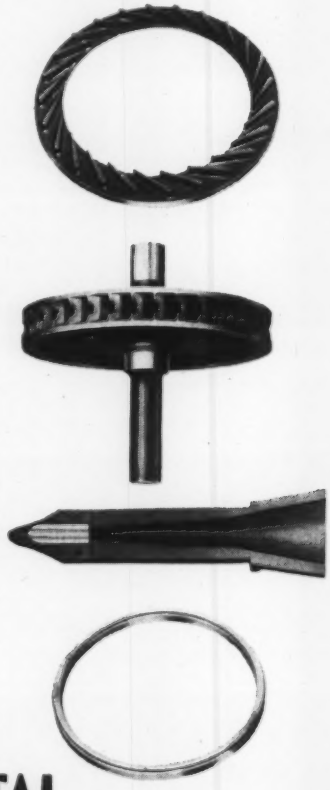
A square of K161B Kentanium and a similar square of a well-known, heat-resistant 35 chromium-15 nickel alloy were exposed for 120 hours in an unsealed muffle furnace heated to 2000°F. The accompanying photographs vividly show how each piece was affected. While Kentanium is still good for hours of exposure at high temperatures, the nickel-chrome alloy has oxidized badly and has begun to disintegrate.

This demonstration suggests how well Kentanium will perform in such applications as furnace parts, heat-treating fixtures, quench guide rings, turbine blades, nozzle vanes, bushings and other parts where strength at high temperature, plus high resistance to oxidation, are factors.

Parts illustrated at the right are typical applications of Kentanium. The Kentanium series represents only a part of Kennametal's wide range of hard carbide compositions that are helping designers who require metals offering high resistance to abrasion, deflection, deformation, impact or corrosion. Perhaps one or more of these Kennametal compositions will help you get your idea off the drawing board into production. These materials are described and many applications discussed in two booklets: B-111-A—"Characteristics of Kennametal," and B-222—"Designing with Kennametal."

Write KENNAMETAL INC., Latrobe, Pa.

*Registered Trademark B-8976



INDUSTRY AND KENNAMETAL ...Partners in Progress

Circle 617 on page 19

ENGINEERING DEPARTMENT EQUIPMENT

Probe Actuator

positions temperature and pressure probes

Actuator for positioning aerodynamic probes uses hollow screw through which probe is inserted and secured with a collet. Two 28-v dc motors, driving through gearing, impart linear and angular motions to probe and screw. Traverse motion extends or retracts probe to permit surveying radially with respect to axis of test unit. Angular motion rotates probe about its own axis to permit probe

head to be automatically aligned for yaw or angular air flow through test unit. Ten-turn potentiometer, geared to each motion, provides output for control and indication. Maximum probe diam is ½-in., traverse motion range is 4 to 20 in., and angular motion is 180 deg. Mechanical counters assist in initial alignment of actuator and probe on test unit with respect to yaw. **L. C. Smith Co.**, 2301 Bradley Rd., Westlake, O.

—Circle ITEM 490

Force Gage

has scale ranges from 100 to 5000 lb

Force gages for accurate measurement of dynamic forces in any system or structure provide large, self-generated outputs of approximately 5 v full scale. Available in full scale ranges of 100, 500, 1000,

Design "Low Cost" Into YOUR Equipment

GITS

World's Largest Selection of Low-Cost Lubricating Devices

ment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

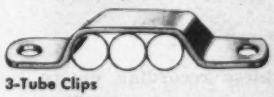
Special Introductory Price
Just $14.95 F.O.B. Factory
Satisfaction or your money back

LIPS FOR ATTACHING UBING

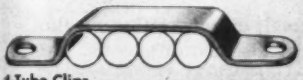
When ordering, pecify ¼", ⅜" ⅛" tubes. tyle TF.

Single Clips

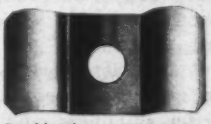
Double Clips



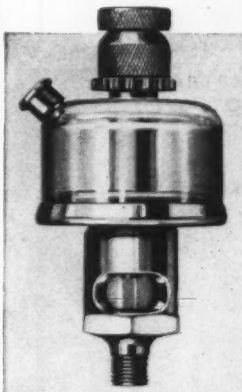
3-Tube Clips



4-Tube Clips

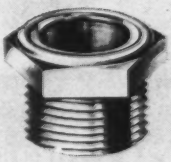


Double Clips — Wing Type



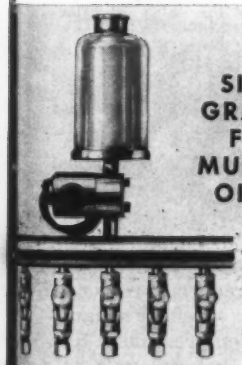
SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.



GEAR CASE GAUGES

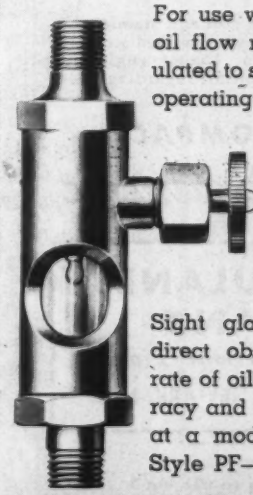
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

is one unit replaces 3 to 8 dividual oilers. Maximum cticality in a small central brication system. Positive cut during idle periods. Individ- vibration-proof needle valve justments. With solenoid con- (Illustrated): Style MDS— . 4685-A. Without solenoid: le MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

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Circle 618 on page 19

New ULANET FM Thermostats protect and control machines, equipment and processes—

SPECIAL HIGH TEMPERATURE STRAIN RELIEF PROTECTED LEAD WIRES

Rapidly respond to extremely close temperature variations in:

LIQUIDS, SOLIDS, GASES, HEATED SURFACES AND AMBIENT TEMPERATURES

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1200 WATTS
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TEMPERATURE RANGE
0° to 600° F.

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- VIBRATION AND SHOCK RESISTANT
- COMPLETELY SEALED
- PROVED IN SERVICE

Two of the exclusive features of the Ulanet FM Thermostats are:

1. The complete lack of reliance on the expansion of the outer shell for make and break of contacts. This permits greater mounting flexibility and freedom from erroneous operation when clamped or when slight pressure might be applied to the outer shell during use.

2. Lead wires are mechanically strain relief protected to prevent external movement of the wire from being transferred to the contact members in the enclosure.

The relatively low cost and stamina of these units merits your immediate further investigation. Ulanet engineers will be glad to consult regarding specific applications.

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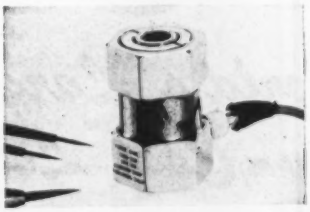
ULANET
ELECTRIC HEAT CONTROL ENGINEERS

GEORGE ULANET COMPANY
Thermostats, Thermal Timers
417 MARKET ST. NEWARK, N. J.

Circle 619 on page 19

Engineering Equipment

and 5000 lb, units have unloaded natural frequency range from 20 kc to 50 kc, providing flat frequency response to at least 5000 cps. Design of gage permits inclusion as part of support structure or coupling linkage. Basic



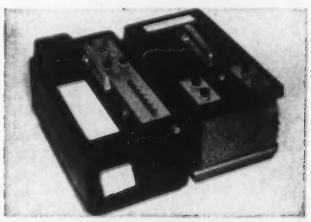
electro-ceramic sensing element provides large output and linearity at temperatures from −65 to +230 F. Uses include testing dynamic properties of plastics, measuring dynamic driving forces in vibration tables and measuring shock forces in ejection mechanisms and shock absorbers. **Endevco Corp.**, 161 E. California St., Pasadena, Calif.

—Circle ITEM 491

Oscillograph

has inkless recording device

Two-channel, direct-writing oscillograph provides instantaneous, permanent recording of frequencies to 250 cps at 1 in. double amplitude. Equipment, consisting of Datagraph and amplifier, records voltage from magnetic-tape playback units, carrier amplifiers, audio amplifiers, dc amplifiers, telemetering discriminators, etc. Almost any input device may be used because



of instrument's high input impedance. Unit has frequency response flat to 250 cycles, excellent square-wave, and transient response. Recorder uses no ink, employs a vibrating wire in a strong magnetic field provided by a permanent magnet. Wire burns contact on electro-sensitive paper as it travels over an anvil, providing rectilinear

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NEW fatigue-proof STEEL BAR

..the bar that has HIGH STRENGTH without heat treating

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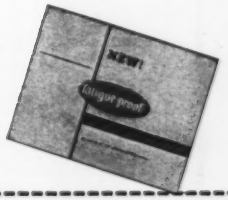

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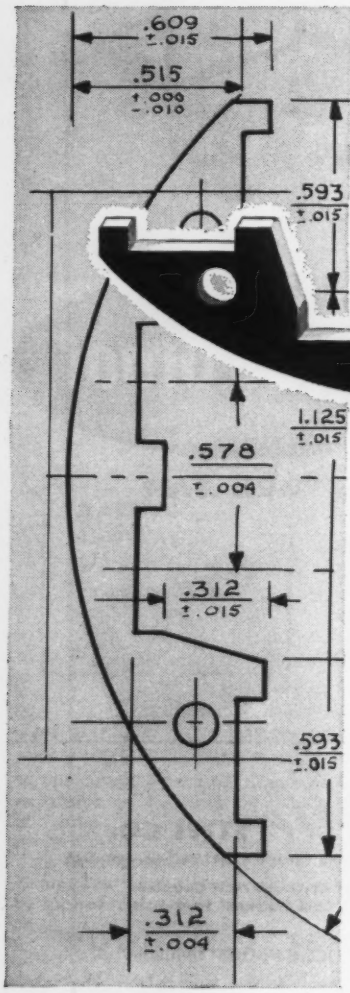
Channel valve assembly with carbon guides. Courtesy: Ingersoll-Rand Company, New York.

Channel valves like this have superior quality built in with carbon guides



Many quality-minded manufacturers, like Ingersoll-Rand, have found that a carbon graphite part in a vital spot betters the performance and adds longer life to their product.

The self-lubricating property of carbon-graphite keeps wear to a minimum and insures a smooth-running, trouble-free machine.

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Circle 621 on page 19

Engineering Equipment

writing. Speed-change buttons select one of six chart speeds from 0.05 to 20 in. per second, and separate control knobs set the trace density for each of the two channels. Timing pulses are from one to five per second. **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif.

—Circle ITEM 492

Five Digit Ratiometer

measures ratio of two dc voltages

With a range of 00.000 to 99.999 and accuracy of 0.01 per cent of reading, ratiometer measures the ratio of two dc voltages, E_1 and E_2, where E_1 is derived from E_2, and E_2 drives the bridge of the ratiometer and also the test unit. The measurement is displayed to five digits with E_1's true in-line read-out. Maximum resolution is 1 part in 100,000, input impedance is 1000 megohms, and E_2 bridge

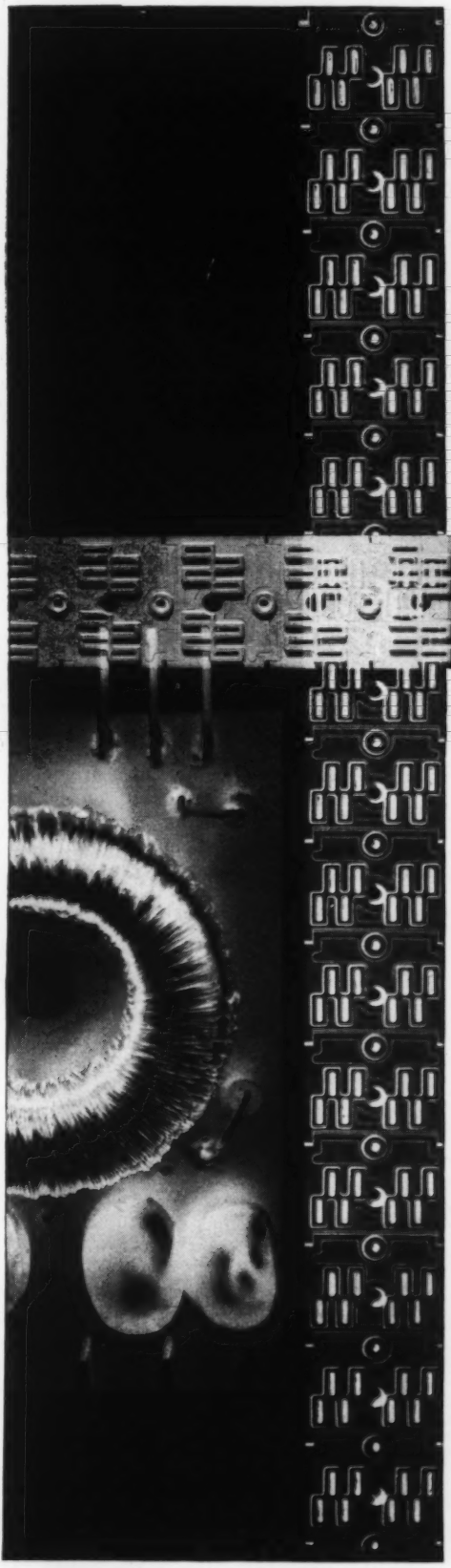
excitation may be either internal or external. The unit is designated R105, and measures 7 by 19 in., with power requirements of 115 v, 60 cycles, 75 w. A switch is located on rear panel for negative bridge excitation. Optional features include a remote read-out and printer operation. **Electro Instruments Inc.**, 3794 Rosecrans St., San Diego, Calif.

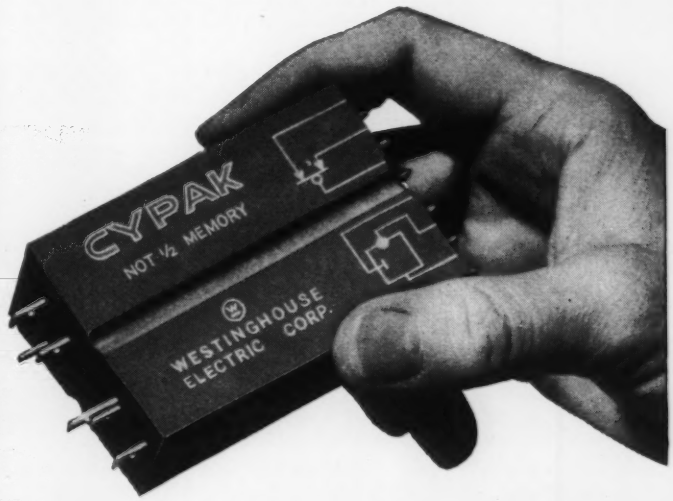
—Circle ITEM 493

Pressure Pickup

miniature transducer requires no cooling

Variable-resistance type transducer operates continuously at temperatures to 600 F, providing accurate pressure measurement under severe environmental conditions. Instrument is available in both gauge





THIS IS CYPAK

for more flexible industrial control

In the flexibility of CYPAK* lies the challenge to throw out mechanical relay limitations and simplify control for more automated production.

For example, CYPAK systems employ just four different component panels. They provide, in the most practical form, the four basic logic functions of computer science. With infinite combinations of these panels you can direct, far more simply, a greater range of equipment operations.

Because the magnetic "make and break" of CYPAK circuits has no moving parts, it is five times faster than mechanical relays. It's the basic reason for CYPAK flexibility in handling control signals.

In addition, CYPAK systems are designed for physical flexibility. A common power channel is the backbone of each system. Into it CYPAK elements are *plugged in*, *locked in*, and signal terminals joined. In this manner, the system is easily expanded or replacements made after installation.

Look into all the new opportunities in CYPAK by calling your Westinghouse sales engineer.

Write today for your free copy of *The Whys and Wherefores of* CYPAK, Booklet B-6584. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-01005

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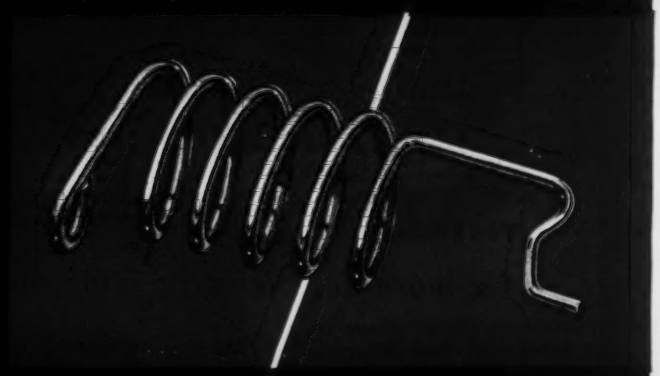

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Accurate *CREATES* a Spring
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Accurate Spring combines old fashioned
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Accurate Springs

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WIRE FORMS
STAMPINGS

ACCURATE SPRING MANUFACTURING COMPANY
3824 W. Lake Street • Chicago 24, Illinois
Circle 623 on page 19

Engineering Equipment

and differential types. Internal metal-to-metal bonds are welded to eliminate creep. Unit is ½-in. diam, ¾-in. long, and, with 30 in. of insulated 4-conductor cable, weighs 15 grams. Pickup is suited for applications where cooling is impractical, such as in dynamic flight - load testing and engine studies. **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif.

—Circle ITEM 494

Vertical Drafting Board

has self-healing drawing surface

Board is of light-weight, aluminum-lined honeycomb sandwich construction which is warp-proof and rigid, mounted in a frame of tubular steel with cast connecting members. Moving members are counterbalanced, and a 20-in. vertical adjustment of the board is

provided, with foot-operated lock. Drawing surface is a self-healing, nonglare plastic which recovers from pencil indentations and compass pointers, maintaining a smooth working area. Board is available in two models, one with fixed angle of 15 deg, the other adjustable 85 deg from vertical. **L.A.B. Corp.**, 1066 Onondaga St., Skaneateles, N. Y.

—Circle ITEM 495

Stress Relief

OUR OLD friend, J. P. Henderson returns from a trip this issue with some observations on

The Revolving, Visiting Fireman

Several weeks ago I had to go to Pittsburgh, and after a busy day there I stopped in at a b-r for some refreshment. Seated comfortably, with a similar aim, was my old friend Joe, whom I had not seen in several years.

After the customary exchange of unpleasantries, he explained to me that he was in high humor because he had perpetrated a mean, unethical, and dastardly trick that day on an acquaintance.

"For years and years," he explained, "there have been two groups of people who have caused me sleepless nights and a red face —consulting engineers and visiting engineers.

"It comes about this way. From time to time we have hired a consulting engineer who reports directly to the president. His work is not on problems connected with my engineering department — except remotely.

"Every time Doc shows up I know I'm in for trouble. Among his other duties he takes a look at our various problems and products. Just in a superficial way, you understand. But he sounds off to the boss.

"The first time this happened the boss called me over to his office and there sat Doc.

" 'Say, Joe,' says my boss. 'Doc here has a half-dozen or so suggestions that sure look good. Why don't we put an oscillating cam on our whatsit? And another thing, why don't we eliminate some of that gearing on the big model?'

Well Joe's boss went through a whole series of suggestions, all of which Joe had to explain away as best he could. The next time Doc showed up, history repeated itself.

(*Continued on Page* 210)

PANELOC

panel fasteners used exclusively on Curtiss-Wright Turbo Compound engines!

Here's why Curtiss-Wright engineers choose PANELOC.

STRENGTH-WEIGHT RATIO! The strength of PANELOC Panel Fasteners is so far in excess of requirements of governing specifications that fewer fasteners are required to do a particular job. This saves the weight of extra fasteners.

LONG LIFE! PANELOC Panel Fasteners are still operative when baffles and ducts wear out. Maintenance is thereby reduced to a minimum. The need for replacements is virtually eliminated.

ECONOMY! The cost of extra fasteners is eliminated and the cost of installation and maintenance reduced when PANELOC Panel Fasteners are used.

Write for catalogues and price lists on Styles 1, 2 and 3 Panel Fasteners.

A product of SCOVILL

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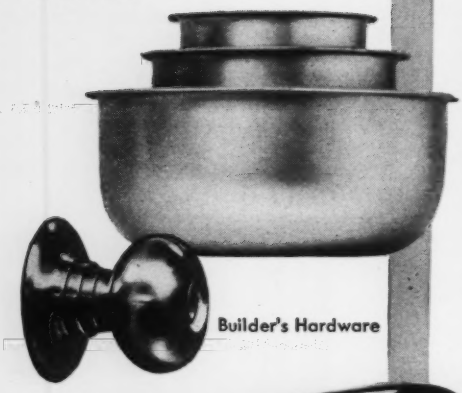
Circle 624 on page 19

Housewares



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Favorable reports on the fabrication of A.I.S.I. Types 201 and 202 are flowing in from manufacturers of a wide variety of stainless steel products ranging from sinks and housewares to hub caps and trailer trucks.

These reports clearly indicate that the 200 series can be fabricated on present equipment without difficulty—without any additional investment in tooling, in most cases. And possibly at savings in certain operations. In fact, skilled equipment operators—the men who work with stainless day after day—have been unable to distinguish between the 200 series and other types when they were intermixed in production runs.

The 200 series is a relatively new member of the family of Republic ENDURO® Stainless Steels. It offers high strength, corrosion-resistance, and easy formability, including draw-bench forming, roll forming, brake bending, blanking, stamping, embossing, trimming, deep and shallow drawing, welding.

Consideration of 201 and 202 for design and fabrication of your present or projected items should be based on the merits of these two types and not as alternates for other grades. However, they are being used interchangeably with other grades.

Our booklet, No. 735, has the latest information on the properties, test evaluations and potentials of these new austenitic stainless steels containing 17% Cr—4% Ni—6% Mn and 18% Cr—5% Ni—8% Mn. Republic Stainless Steel metallurgists and specialists are ready to help you apply Types 201 and 202 to your production. There's no obligation. Just send the coupon to let us know if you would like a representative to call at your plant.

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Circle 625 on page 19

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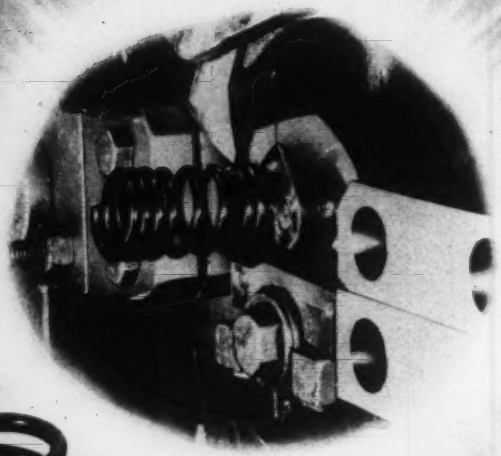

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Circle 626 on page 19

Stress Relief

(Continued from Page 207)

This time the boss called in Joe without Doc being present.

"Joe," he said, "This fellow Doc is just full of ideas. Why I never saw a fellow who has such a keen mind. He just looks around and sees a dozen ways to improve what we're doing or to develop new products. Yesterday he suggested . . !"

"So there I was again," said Joe, "trying to explain to my boss why this wasn't practical, why that didn't work, and so on. And the more I talked the more sour became the expression on his face. I could see very well what was going through his mind. He thought me bull-headed, unco-operative and full of professional jealousy.

"I know we're not perfect. A few of Doc's ideas were good. But here was our department, getting ulcers, working hard for years trying to do a good job. But in any product or product development, sales attitude, manufacturing facilities, various specifications—a million conditions—put restrictions on you or provide perfectly sound reasons for your not being able to do this or that.

"Then in walks a visitor, who doesn't know any of that, who sounds off to the boss, puts us all in bad, and walks out again."

"But what happened today?" I asked.

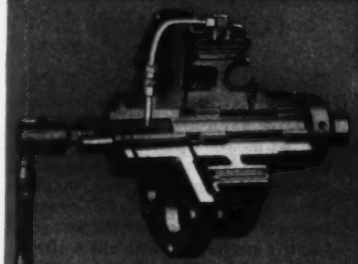
Joe got a beatific though somewhat glassy look in his eye.

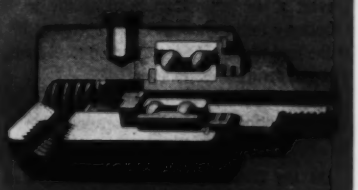
"Here I've been talking about Doc when actually it's Trevor I'm concerned about. You know Trevor? He's chief engineer of the Smith company here. He knows my boss and he visits us from time to time. The boss always takes him around and shows him the works.

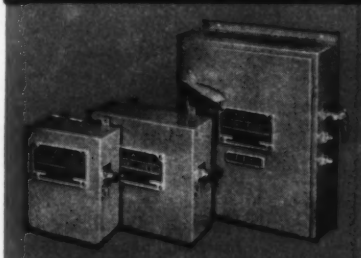
"Darn me if after that first visit, the boss didn't call me up and tell me what a smart fellow Trevor was. Just full of ideas. Had some valuable suggestions. For instance, we should probably increase the gearing in that big model. And so on, and so on.

"Trevor's not in our line of work and he sounded off with only the most elementary idea as to what our problems are. Maybe he does have a keen mind but three times now that guy has made me look

high-speed production with FAWICK clutches & brakes







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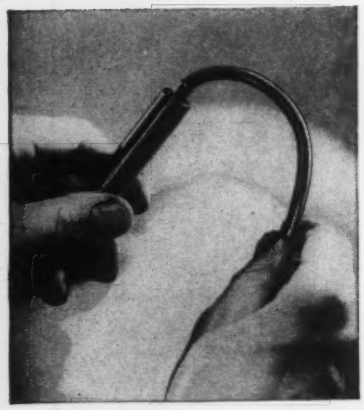

New spring stress reliever increases operating life

CHROMALOX *Electric* CARTRIDGE HEATERS

On applications which require repetitive flexing action, you can now obtain Chromalox Electric Cartridge Heaters equipped with an ingenious high tensile spring—which protects the lead wire against premature breakage.

The spring—which is mechanically locked to the cartridge heater and is not affected by heat—follows the lead wire a sufficient distance to prevent sharp twists from breaking the wire. Laboratory testing indicates that operating life of the lead wire can be increased up to 10 times with this spring stress reliever.

Chromalox Electric Cartridge Heaters equipped with the spring stress reliever are available in ⅜″, ½″, ⅝″ and ¾″ diameters.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically.

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for more specific information on Chromalox Electric Cartridge Heaters.

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City_____ Zone____ State_____

A-4497A

Circle 628 on page 19

Stress Relief

like an unco-operative ignoramus.

"Today I had an invitation to visit Trevor's boss. *He* showed *me* around. And, boy, did I fix Trevor. I made a million suggestions. All very tactfully, you know. I praised their product but wondered why they had never tried this or that. I looked a little dubiously at some of their designs and carefully made suggestions. Lots of them.

"I'll bet you my last nickel that tomorrow Trevor is on the pan. I'm sure that I've established a reputation as a keen mind. Boy, I'm full of ideas. Let *him* explain 'em away to *his* boss tomorrow."

"And some day I'm going to get Doc, too."

On the train coming home I gave a lot of thought to Joe's conversation. In some respects engineering is far removed from a professional basis. I doubted if either Doc or Trevor were maliciously attempting to make trouble for Joe. Perhaps they never considered they were being unethical. Or weren't they? Perhaps they never realized the extent to which they were sounding off without a real background for judgment.

I thought of the legal and medical professions. Could you imagine calling a second doctor in on a case and having him tell you (without the first doctor being present) that you didn't have flat feet at all. With little or no examination—telling you your trouble was this or that and your past treatment was all wrong? If a physician would do that, you would probably consider it highly unethical or brand him as a quack.

Instead, he is there partially through the sufferance of the original doctor. They probably have a series of conferences concerning your past history and tests. And recommendations are probably discussed between them before you as a patient are ever aware of them. You don't catch one of them selling out a colleague to a patient.

Is that sort of attitude necessary in engineering? Were Doc and Trevor unethical? Or was the whole trouble with Joe's boss because he was tactless, inconsiderate, and not understanding? Well?

—J. P. HENDERSON

YOU WOULDN'T BUY

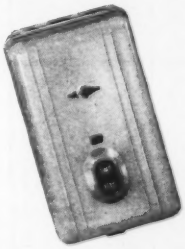
A HAT THAT'S TOO BIG!

SO WHY BUY A CONTROL THAT'S THE WRONG SIZE?

FURNAS

MAGNETIC CONTROLS GIVE YOU CORRECT CAPACITY FOR THE JOB!

The many in-between sizes in the Furnas Electric starter line let you select the motor control that is best suited for your particular requirements—with no wasted capacity and expense. Match the starter to the job and save up to 25%. For proof, compare the 9 sizes of the Furnas Electric starter line with the 5 sizes normally offered. And you can save up to 40% in space by using the correct size starter.



For more information write for Bulletin 5530—1045 McKee Street, Batavia, Ill.

A11

FURNAS

FURNAS ELECTRIC COMPANY

BATAVIA, ILLINOIS

Sales Representatives in all principal cities

Circle 629 on page 19

SPEED TREAT Steel Plate is truly versatile!

Rotary Printing Press
"Honeycomb" Plate Cylinder

One of the many intricate machines manufactured by Western Printing Machinery Company, Chicago, Illinois is a rotary printing press third color unit. The "Honeycomb Plate" cylinder shown here is fabricated from eight pieces of 1" x 9¾" x 59" Speed Treat Plate, each rolled to 20" diameter and resistance welded. The inner and outer diameters of the rings are machined and a total of 16,936 holes step-drilled from the outside and counterbored from the inside. The eight segments are then assembled to form a complete cylinder and finish ground. Since the adoption of Speed Treat Steel Plate it is not uncommon to counterbore all of the holes without resharpening the tool. As many as 32 counterbores have been broken in completing one cylinder made of C-1045 forged rings formerly used for this application. The customer estimates that 30% savings result from the superior machinability of Speed Treat Steel, the elimination of tool breakage and minimized tool sharpening.

Ask for our New Speed Steel Plate Bulletins:

Bulletin 541— SPEED CASE	low carbon free machining open hearth steel plate
Bulletin 542— SPEED TREAT	medium carbon free machining open hearth steel plate
Bulletin 543— SPEED ALLOY	High quality chrome-manganese alloy steel plate

THE SPEED STEELS ARE DISTRIBUTED COAST TO COAST BY THESE WAREHOUSES

Beals McCarthy & Rogers, Inc.
Buffalo, N. Y.

Bridgeport Steel Co.
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Burger Iron Co.
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Peninsular Steel Co.
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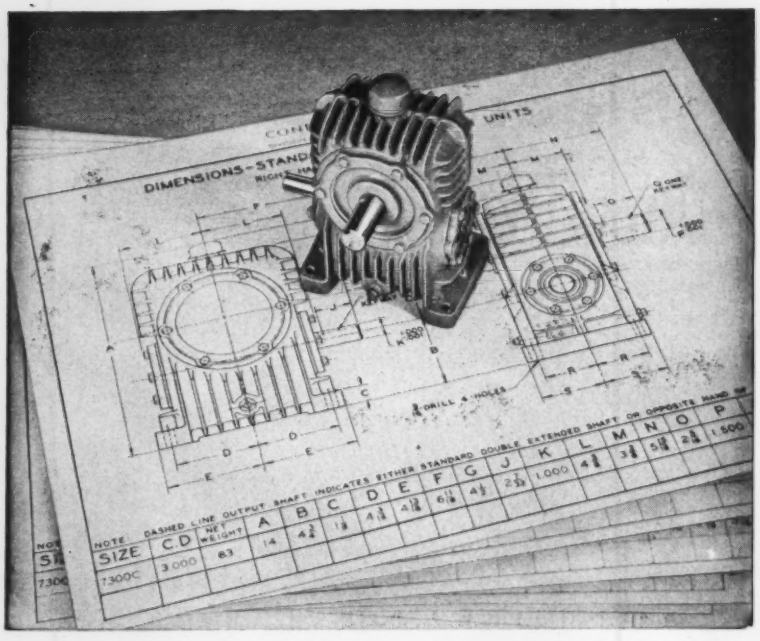
Jones & Laughlin Steel Warehouse Division
Chicago • Cincinnati • Louisville • New York

W. J. Holliday & Co. Warehouse
Indianapolis, Indiana

SPEED STEELS

JONES & LAUGHLIN STEEL WAREHOUSE DIVISION
INDIANAPOLIS 7, INDIANA

Circle 630 on page 19


DIMENSIONS - STAND
UNITS
NOTE DASHED LINE OUTPUT SHAFT INDICATES EITHER STANDARD DOUBLE EXTENDED SHAFT OR OPPOSITE HAND
SIZE C.D NET WEIGHT A B C D E F G J K L M N O P
7300C 3.000 83 14 4½ 1⅜ 4½ 4½ 6½ 4½ 2⅝ 1.000 4⅜ 3⅜ 5⅜ 2⅜ 1.500

DIMENSIONS ONLY TELL HALF THE STORY...

. . . about worm gear speed reducers. You've got to compare size with load capacity for the whole picture. Inside a Cone-Drive speed reducer you'll find the double-enveloping worm gear design that makes it the most efficient right-angle speed reducer available.

Take the standard 3″ center distance unit above for example. Here are its Class I Service Ratings with a 5:1 reduction:

Worm RPM	100	200	300	580	720	870	1150	1750
Mech. HP	1.24	2.21	3.08	4.89	5.61	6.34	7.41	9.04
Thermal HP	1.24	2.21	3.08	4.20	4.62	5.10	6.00	7.80
Output Torque (inch-lbs.)	3340	3010	2830	2405	2250	2150	1940	1575

That's a lot of capacity for a unit that occupies less floor space than this magazine page. But it's typical of Cone-Drive speed reducers and gearsets. Complete details on this model in Bulletin 600-C. Other units to 800 HP and ratios to 4900:1.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

Circle 631 on page 19

THE ENGINEER'S Library

Recent Books

Strength of Materials, Part II: Advanced Theory and Problems, 3rd Edition. *By Stephen Timoshenko, professor emeritus of engineering mechanics, Stanford University;* 572 *pages,* 6 *by* 9 *in., clothbound; published by D. Van Nostrand Co. Inc., Princeton, N. J.; available from* MACHINE DESIGN, $7.50 *postpaid.*

Major changes in this edition occur in the chapters on torsion, plastic deformation and the mechanical properties of materials. Throughout the revision, new references, probems and illustrations have been added. Chapters deal with beams on elastic foundations, beams with combined axial and lateral loads, bending of beams, thin plates and shells, buckling of structures, symmetrical deformation, torsion, stress concentration, deformations beyond the elastic limit and properties of materials.

♦

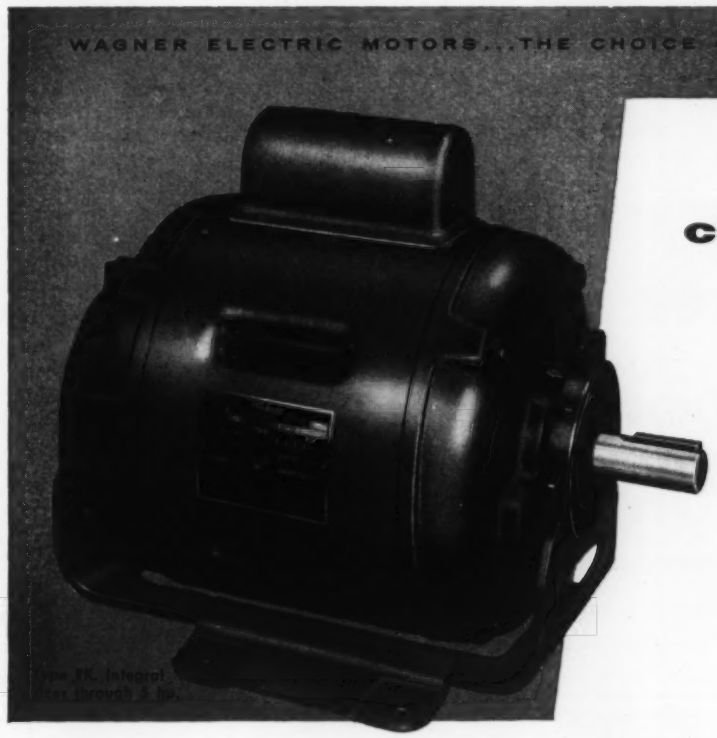
Electronics in Management. *Edited by Lowell H. Hattery and George P. Bush;* 207 *pages,* 6 *by* 9 *in., clothbound; published by The University Press of Washington, D. C.,* 1621 *Connecticut Ave. N.W., Washington* 9, *D. C.; available from* MACHINE DESIGN, $6.00 *postpaid.*

Adapted from the proceedings of the First Institute on Electronics presented at The American University in November 1955, this book summarizes advanced thinking about management implications of electronic computers. Twenty-one contributors give their considerations and experience in engineering, scientific and administrative applications of computers.

♦

Principles of Turbomachinery. *By D. G. Shepherd, professor of mechanical engineering, Cornell University;*

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY



choose these smaller, lighter, motors... for modern equipment

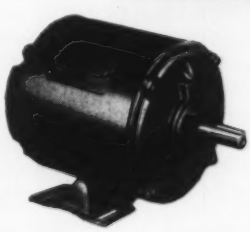
For years Wagner motors have been the first choice of many leading manufacturers of air conditioners, refrigerators, freezers, water pumps and motor-driven tools. They meet the requirements of many other similar applications because of their high starting torque and low starting current.

Now these Wagner motors are lighter in weight and smaller in size. This means that you can design smaller motor housings—build lighter motor mountings. Wagner motors are easier to handle and easier to stock because they take up less space.

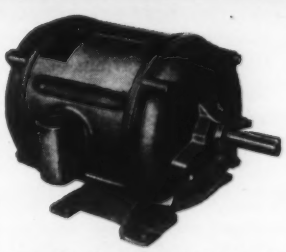
And these motors offer low maintenance costs—only a minimum of servicing is required—they give many years of reliable service with unusual freedom from vibration and noise.

Available in repulsion-start or capacitor-start types—open or totally-enclosed—sleeve or ball bearing—with rigid or resilient bases or machined endplates for flange mounting. Write today for Bulletin MU-185 which gives complete information.

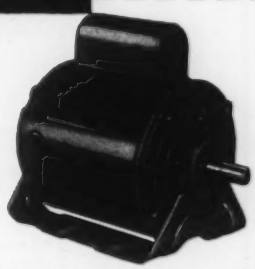
A Complete Line—Single-phase and Polyphase Motors



Type RP, Polyphase fractional horsepower motors. Available in ⅛, ¼, ⅓, ½, and ¾ hp ratings. Rigid or resilient base—sleeve or ball bearing.



Type RA, Repulsion-start induction-run single-phase motors. For applications requiring high starting torque. ½ to 15 hp.



Type RK Capacitor-start. ⅓, ½, and ¾ hp . . . sleeve or ball bearings. The resilient mounting offers unusual freedom from vibration and noise.

Wagner Electric Corporation
EST. 1891

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo., U. S. A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS-AIR AND HYDRAULIC

M56-5

This New PIONEER Coolant Pump gives you Important Advantages

1. Totally enclosed motor, with extra-heavy shaft and heavy-duty ball bearings.
2. Handles abrasives or chips without injury to the pump.
3. Will pump down to 1 1/16"; self-priming to 1" liquid level.
4. Permits clean-out of machine sump with minimum time and labor.
5. Interchangeable with any make pump with standard mounting dimensions.
6. Sealless design with no metal-to-metal moving parts.
7. Can be furnished with any desired electrical characteristics.
8. Three optional outlets: left external, right external, center outlet through mounting flange. The latter permits compact, clean-cut design of machine with no exposed piping.

Pioneer offers more than 400 models of impeller-type and positive displacement pumps to meet every coolant pump requirement; or we will develop designs for specific applications. Our application engineers will welcome the opportunity to discuss your pump requirements with you.

Send for our illustrated booklet covering the basic Pioneer designs in both impeller-type and positive displacement pumps.

PIONEER PUMP DIVISION
DETROIT HARVESTER COMPANY
Sales Office: 5450 West Jefferson Ave., Detroit 9, Michigan
Plant: Paris, Kentucky

Circle 633 on page 19

The Engineer's Library

463 pages, 6 by 9 in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from MACHINE DESIGN. *$10.00 postpaid.*

This text outlines the basic principles of all forms of turbomachines and presents detailed analyses of the most important types from the viewpoint of the mechanical engineer. Chapter subjects are: dimensional analysis, energy transfer between a fluid and a rotor, thermodynamics of gas flow, flow of fluids in turbomachines, centrifugal pumps and compressors, radial-flow turbines, axial-flow turbines, performance of turbines and comparison of types, axial-flow compressors and pumps, and performance of compressors and pumps.

Association Publications

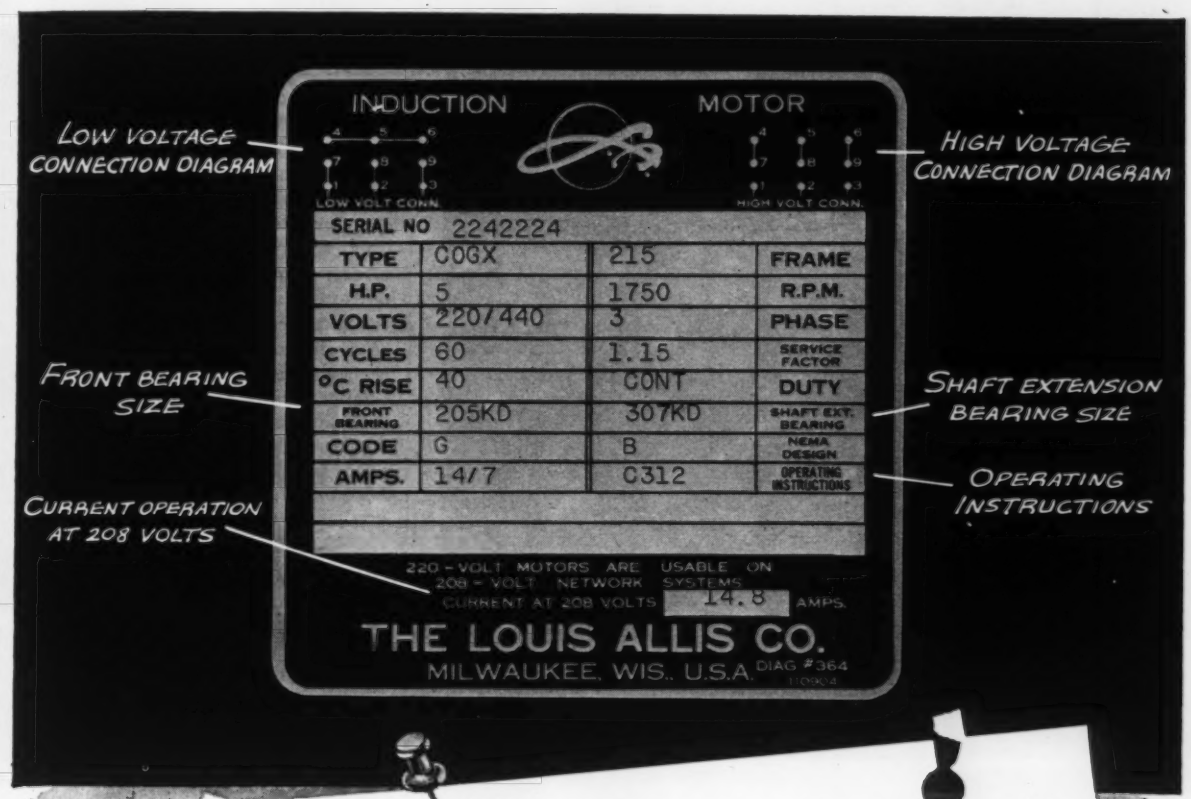
Handbook of Welded Steel Tubing. *267 pages, 8½ by 11 in., spiral bound; published by and available from the Formed Steel Tube Institute, 850-52 Hanna Building, Cleveland 15, O., $10.00 per copy.*

This handbook is divided into two main sections. The first is on carbon-steel tubing, the second on stainless-steel tubing. Both sections give applications, physical information, tolerances, ordering information, physical properties, fabrication data, and design information. Design and fabrication data are presented for cutting, bending, swaging, flanging, expanding, brazing, welding, and mechanical joining. A third section in the book provides design data tables and a glossary.

•

Recommended Practice for Office Lighting. *32 pages, 8¼ by 11 in., paperbound; prepared by the Committee on Office Lighting of the Illuminating Engineering Society; available from Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.; 50c per copy.*

This report includes results of consultation over the past six years with representatives of the


LOW VOLTAGE CONNECTION DIAGRAM
INDUCTION MOTOR
HIGH VOLTAGE CONNECTION DIAGRAM
LOW VOLT CONN.
HIGH VOLT CONN.
SERIAL NO 2242224
TYPE C0GX 215 FRAME
H.P. 5 1750 R.P.M.
VOLTS 220/440 3 PHASE
CYCLES 60 1.15 SERVICE FACTOR
°C RISE 40 CONT DUTY
FRONT BEARING 205KD 307KD SHAFT EXT. BEARING
CODE G B NEMA DESIGN
AMPS. 14/7 C312 OPERATING INSTRUCTIONS
FRONT BEARING SIZE
SHAFT EXTENSION BEARING SIZE
CURRENT OPERATION AT 208 VOLTS
OPERATING INSTRUCTIONS
220 - VOLT MOTORS ARE USABLE ON 208 - VOLT NETWORK SYSTEMS
CURRENT AT 208 VOLTS 14.8 AMPS.
THE LOUIS ALLIS CO.
MILWAUKEE, WIS., U.S.A. DIAG #364

why is this nameplate important to you?

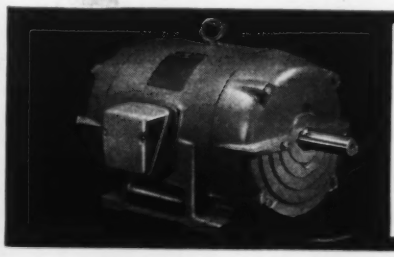
It provides visible evidence that Louis Allis standard motors are built with special care to run better, last longer . . .

Look at the information on this nameplate—information that makes life a lot easier for the user. And to keep this information available at all times, we make this nameplate out of corrosion-resistant stainless steel.

Yes, in the new LA line of standard motors, even the nameplate gets special attention from our engineers. And here's what it means to you:

- The rerated frame size shown means more horsepower from motors with smaller outside dimensions. Performance has been improved by new materials and manufacturing methods.
- Spare bearings can be easily ordered from bearing size and type designations on nameplate, thus eliminating disassembly of motor to determine bearing size. Bearings used are conservatively rated for long life.
- No more lost connection diagram since this information is simply and clearly shown on nameplate. This combined with permanent lead markings, assures that correct motor connections can always be made.
- 220/440 volt motors are suitable for operation on 208 volt systems and full load current for 208 volt operation is included on the nameplate. This eliminates need for original equipment manufacturers to carry a stock of 208 volt motors.

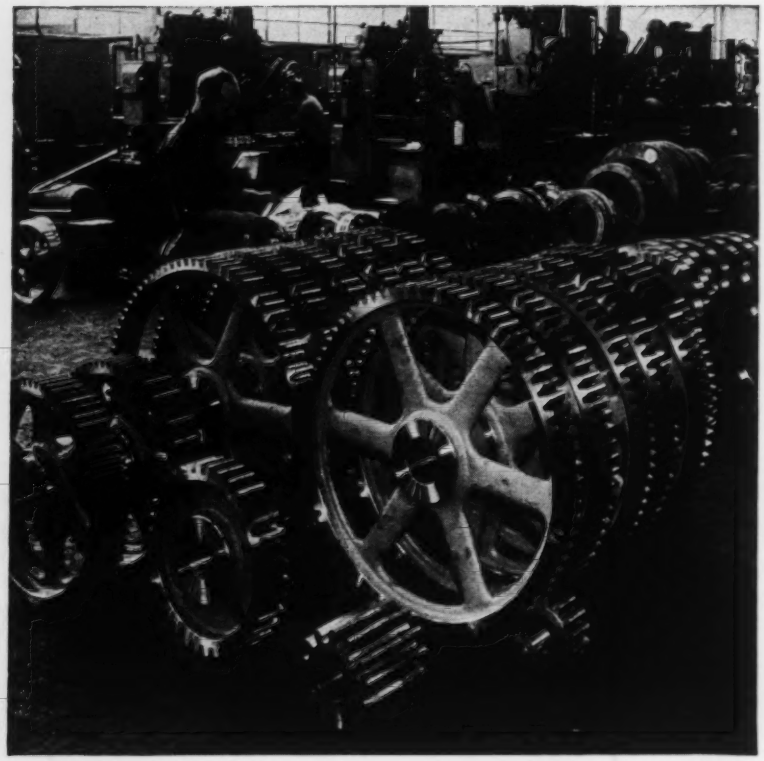
Because they are built with special care, new LA standard motors can do a lot more for you. New bulletin No. 1700 shows you why—just write for your copy.



A complete line of standard rerated motors in frames 182 through 326U now in stock. Special rerated motors are available on short delivery.

LA-106

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN



DESTINATION -Soaking Pits

These H&S steel spur gears will soon be lifting soaking pit covers for a leading steel producer. (We cut spur gears up to 144" outside diameter and 1 D.P.)

Similar large H&S custom-built spur gears have proved their dependability by serving Industry for over 50 years. Rugged construction and exact machining of all H&S gears assure quiet operation, uniform velocity ratio and freedom from vibration.

Let our years of experience in the engineering and manufacture of all types of gears be your assurance of an unbiased recommendation for the best solution to your requirements. Contact your H&S representative or send us your power transmission inquiries today.

THE HORSBURGH & SCOTT CO.

GEARS AND SPEED REDUCERS

5112 Hamilton Avenue
Cleveland 14, Ohio

Circle 635 on page 19

The Engineer's Library

I.E.S. Committee on School Lighting; the American Institute of Architects; and the National Council for Schoolhouse Construction. Based upon the concept of lighting for specific tasks, the introduction is a summary description of office operation. Two following sections cover influence of lighting on seeing and influence of environmental factors. Two more sections deal with lighting systems and specific areas, including drafting rooms. The final chapter covers maintenance, including specific plans for cleaning and relamping and a sample expense analysis worksheet.

•

Design and Construction of Steel Merchant Ships. *David Arnett, editor; 494 pages, 8 by 10¾ in., paperbound; published by The Society of Naval Architects and Marine Engineers, 74 Trinity Place, New York 7, N. Y.; $14.00 per copy.*

For designers in the shipbuilding and allied fields, this book summarizes the field covered by its title. Chapters cover basic design; structural design; joining structural parts; fittings; cargo-handling; mooring, towing and steering arrangements; piping systems; ventilating, heating and cooling; lifesaving equipment and aids to navigation.

•

Elevated-Temperature Properties of Coppers and Copper-Base Alloys. *By Clair Upthegrove and Henry L. Burghoff; 248 pages, 8½ by 11 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $5.50 per copy.*

This report presents graphical data concerning the elevated-temperature characteristics of wrought copper and cast and wrought-copper alloys. Data include modulus of elasticity, tensile strength, yield strength, reduction of area, elongation, creep rate stresses, and rupture stresses. Original data used for drawing the curves are given in an appendix, along with data which were insufficient or

Circle 636 on page 19→

MEMORANDUM

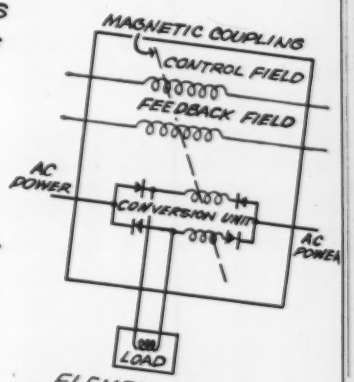
FROM: THE CLARK CONTROLLER CO. TO: OUR CUSTOMERS

SUBJECT: MAGNETIC AMPLIFIERS m/a

HERE ARE THE SIMPLE FACTS ABOUT OUR MAGNETIC AMPLIFIERS:

USED PRIMARILY AS INDUSTRIAL DRIVE REGULATORS ON CONTROL SYSTEMS, THEY CONSIST BASICALLY OF THREE MAGNETICALLY-COUPLED ELEMENTS:

1. A CONTROL FIELD –
2. A FEEDBACK FIELD –
3. A CONVERSION UNIT –

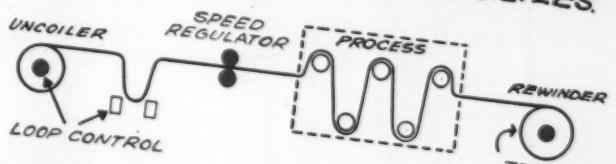


ELEMENTARY MAGNETIC AMPLIFIER

IF CONTROL FIELD AMPERE TURNS EXCEED FEEDBACK FIELD AMPERE TURNS IN A POSITIVE DIRECTION, OUTPUT IS TURNED ON. IF THE REVERSE OCCURS, OUTPUT IS TURNED OFF.

HERE'S HOW THIS IS APPLIED: IN A GENERATOR VOLTAGE REGULATOR, FOR EXAMPLE, THE CONTROL FIELD IS CONNECTED TO A REFERENCE SOURCE OF VOLTAGE, THE FEEDBACK FIELD TO THE ARMATURE TERMINALS, AND THE SHUNT FIELD TO THE LOAD TERMINALS. INCREASING AMPERE TURNS IN THE CONTROL FIELD TURNS ON THE REGULATOR, RAISING GENERATOR VOLTAGE UNTIL FEEDBACK BALANCES CONTROL FIELD, AT WHICH POINT THE SYSTEM STABILIZES.

AMONG THE MANY REGULATING SYSTEMS USING THIS PRINCIPLE ARE: CONSTANT TENSION COIL WINDING, SPEED REGULATION, POSITION REGULATION (LOOP CONTROL, EDGE CONTROL, SYNCHRONIZING CONVEYORS, ETC.).



MECHANICAL SCHEME FOR CONTINUOUS WEB OR STRIP PROCESSING CONTROL

THE MAGNETIC AMPLIFIER HAS ALMOST LIMITLESS APPLICATION AS A "SERVO" DEVICE TO MAINTAIN A PRE-DETERMINED RELATIONSHIP BETWEEN TWO FACTORS AS IN HEAT CONTROL, WEIGHT OR VOLUME CONTROL, PRESSURE CONTROL, TRANSDUCERS, METERING, CONTINUOUS PLATING CONTROL, ETC.

AS YOU CAN SEE FROM THE ABOVE, CLARK MAGNETIC AMPLIFIERS ARE IDEAL FOR USE IN AUTOMATION SYSTEMS. THEY ARE STATIC DEVICES WITHOUT TUBES, THUS REQUIRING NO WARM-UP TIME AND PRACTICALLY NO MAINTENANCE. THEY ARE FACTORY ADJUSTED, SIMPLIFYING INSTALLATION.

Clark's wide experience in applying magnetic amplifiers to industrial drives is at your service.

The CLARK CONTROLLER Company

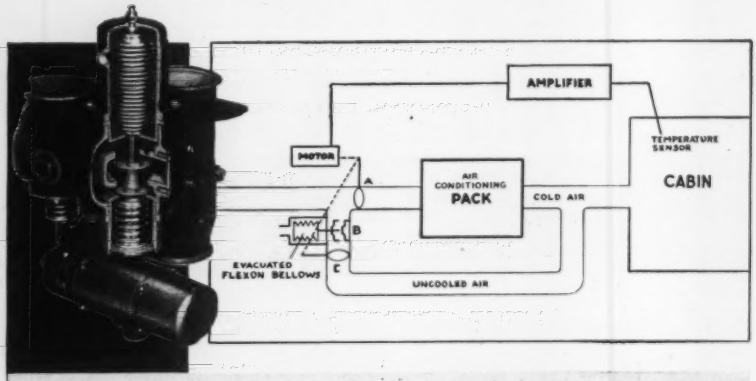
Engineered Electrical Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

FLEXON® BELLOWS *Design Briefs*

Flexon® Bellows Govern Complex Air Conditioner Air Flow Valve

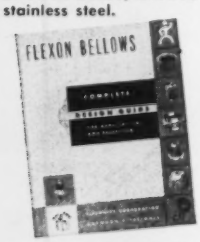


HOW IT WORKS

Valves A and C are connected by linkage and operated by an electric motor controlled by a temperature sensor to maintain a balanced flow of air through the conditioner and the by-pass. When Valve A opens, Valve C closes and vice versa. The Flexon Bellows actuates Valve B to regulate total air flow.

FLEXON® OFFERS THE COMPLETE BELLOWS SERVICE

Flexonics Corporation manufactures a complete range of bellows and bellows assemblies in brass, bronze or stainless steel.



The Flexon Bellows Design Guide gives valuable application and design information. Write for your copy, today.

A Flexon Bellows is the heart of a mass flow valve manufactured by Stratos Division of Fairchild Engine and Airplane Corp., Long Island, New York.

Used in aircraft conditioning systems where upstream pressure varies over a wide range, the Stratos Mass Flow Valve is actually two valves in one body. Combining the features of a cabin temperature control valve and a conditioned flow regulator, its function is to maintain a constant flow of conditioned air to the aircraft cabin. Desired temperature is maintained by a balanced blending of cooled and uncooled air. The Flexon Bellows is used as an aneroid to maintain a constant volume of air regardless of atmospheric pressure. The schematic drawing above illustrates the operating principle.

The Flexon Bellows used in this valve design, like all Flexon Bellows, is cost engineered to meet the specific requirements of the job. To take advantage of this kind of service, send an outline of your requirements.

FLEXON® QUALITY proved in service and backed by over 54 years manufacturing experience

B-41

Flexonics *Corporation*

FLEXON BELLOWS DIVISION

1339 S. THIRD AVENUE, MAYWOOD, ILLINOIS

FORMERLY CHICAGO METAL HOSE CORPORATION

Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

Circle 637 on page 19

The Engineer's Library

too inconclusive to be presented graphically.

Manufacturers' Publications

Heintz Cold Extrusion Data Book. *26 pages, 6 by 8 in., paperbound; prepared by and available on company letterhead request from Heintz Manufacturing Co., Front St. & Alney Ave., Philadelphia 20, Pa.*

This is a data book on the Heintz "CX" application of the extrusion of steel at room temperatures for high-production items. The purpose of the book is to give basic information to help the designer employ the process economically. Subjects covered are: basic movements, use of raw materials, production quantities, size and weight of parts, design details and finishing.

Government Publications

An Investigation of Various Properties of NiAl. *By Richard L. Wachtell, American Electro Metal Co.; 8 by 10½ in., paperbound; prepared for Wright Air Development Center, U. S. Air Force; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; in three sections:*

PB 121021—36 pages—$1.25 per copy.
PB 121022—44 pages—$1.50 per copy.
PB 121023—69 pages—$2.00 per copy.

This three-part report gives the results of investigations of nickel aluminide alloys tested for suitability as high-temperature materials.

•

NACA Technical Series. *Each publication is 8 by 10½ inches, paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics, 1924 F St. N.W., Washington 25, D. C.*

The following Technical Notes are available:

3685. **Fatigue Crack Propagation in Severely Notched Bars**—30 pages.

3713. **Selection of Optimum Configurations for Heat Exchanger with One Dominating Film Resistance**—48 pages.

3726. **Compressive and Torsional Buckling of Thin-Wall Cylinders in Yield Region**—42 pages.

3727. **Influence of Hot-Working Conditions on High-Temperature Properties of a Heat-Resistant Alloy**—134 pages.

3729. **Mechanical Tests on Specimens from Large Aluminum-Alloy Forgings**—25 pages.

Now you can get from PROGRESSIVE Slotted Tapping Screws with an extra customized touch — Slotted Tapping Screws which are custom-made to your order. This means: (1) specifically made for you — not bin stock parts; (2) fast, custom-handling of every order; *plus* (3) the double economy of low initial cost *and* the savings in your assembly operations possible only with high precision, torsion-tested fasteners.

STANDARDS AND SPECIALS CUSTOMIZED FOR YOUR NEEDS

THE PROGRESSIVE MFG. CO.
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Circle 638 on page 19

Earth Satellite's Magnesium Shell—

International News Photos

—typical of B & P's Skill in Fabrication

To a skin of non-uniform thickness of 0.015" to 0.030", interior bracing must be welded or secured with screws. Weight-savings of fractions of ounces can be highly important. The outside, manufactured to a tolerance of four micro-inches, must be polished to an intense mirror brightness.

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Circle 639 on page 19

New Machines

Domestic

Projector: Specialist 500-w projector for single and double-frame filmstrips and 2 x 2 slides provides a bright, uniform picture and very low film plane temperatures when operated out of the case. When used with the case, the temperature is reduced nine degrees with the wind-tunnel cooling system in which the case provides a two-in. high air chamber through which a high-speed, 5-in. fan scoops air into the cooling chamber. Lamp is cooled by air forced into narrowing venturi channels to provide faster flow and rapid cooling. Filmstrips move through the projector on ceramic tracks, with the picture area never touching any stationary part. When finished, film is rolled in a built-in take-up compartment. Operating instructions and a sketch of the film path are mounted on a plate on the side of the unit. Filmstrips can be projected vertically or horizontally, and spliced or bent strips are accepted. Standard lens is fully corrected, 5-in., f/3.5 in a metal barrel. Three other lenses are also available. *Bell & Howell Co., Chicago.*

Color Television Receiver: Consolette 21-in. television receiver is one of four new color models. All units provide 255 sq in. viewable picture and have top front tuning. Improved color-killer circuit automatically cuts out unused color circuits during black and white programs. The consolette has an 8-in. speaker, and 29 tubes plus two germanium diodes. *Admiral Corp., Chicago.*

Phonograph: Festival 420 Model 2S-251B high fidelity phonograph is one of a line of eight new phonographs and radio-phonograph combinations. It employs a two-stage audio amplifier with four push-pull parallel 6V6 power output tubes, giving 20 w undistorted power output. Controls include individual continuously variable treble, bass

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Circle 640 on page 19

Adjustable Speed

Is Your Drive Problem in this List?

AIRCRAFT INDUSTRY
- ☐ Wind Tunnels
- ☐ Dynamometers
- ☐ Accessory Testing

AUTOMOTIVE INDUSTRY
- ☐ Conveyors
- ☐ Machine Tools
- ☐ Presses
- ☐ Dynamometers

CALCINED PRODUCTS
- ☐ Kilns
- ☐ Fans
- ☐ Feeders
- ☐ Conveyors

CHEMICALS
- ☐ Pumps
- ☐ Conveyors
- ☐ Process Machinery
- ☐ Winders

FOOD PROCESSING
- ☐ Mixers
- ☐ Dryers
- ☐ Conveyors
- ☐ Mills

GRAPHIC ARTS
- ☐ Main Presses
- ☐ Press Auxiliaries
- ☐ Winders
- ☐ Slitters

MATERIALS HANDLING
- ☐ Conveyors
- ☐ Cranes
- ☐ Shovels
- ☐ Lift Trucks

MINING
- ☐ Conveyors
- ☐ Hoists
- ☐ Mills

METAL WORKING
- ☐ Rolling Mills
- ☐ Presses
- ☐ Winders
- ☐ Slitters
- ☐ Loop Cars

PULP AND PAPER
- ☐ Paper Machines
- ☐ Auxiliary Helpers
- ☐ Converting Machines
- ☐ Finishing Machines
- ☐ Pulp Processing Machines

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- ☐ Plasticizers
- ☐ Calenders
- ☐ Winders

TESTING
- ☐ Engines
- ☐ Pumps
- ☐ Motors
- ☐ Auxiliaries
- ☐ Wind Tunnels

TEXTILES
- ☐ Winders
- ☐ Slashers
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- ☐ Fans
- ☐ Boiler Feed Pumps
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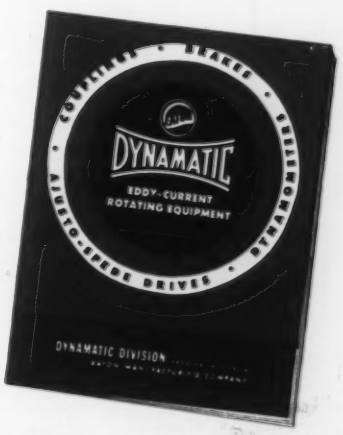

Send for your free copy of the Dynamatic Bulletin GB-2, which illustrates and describes eddy-current adjustable speed rotating equipment.

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Circle 642 on page 19

New Machines

and loudness controls. Two 12-in. heavy-duty bass speakers and two 5-in. coaxially-mounted high frequency speakers equipped with sound diffusers and cross-over network are slanted up for ear-level sound distribution. Pick - up, equipped with dual stylus, requires no preamplification. *Magnavox Co., Spartan Div., Ft. Wayne, Ind.*

Laundry Appliances: New units include five automatic washers, five electric dryers, six wringer washers and an ironer. Washers have an automatic pretreatment, part of the complete cycle, in which water flow into the tub is halted after several minutes, the agitator is started, and clothes are agitated for a minute in a highly concentrated solution of detergent or soap. Electric dryers are equipped with a 5600-w heater. Safety thermostat shuts off the heating element automatically if a safe drying temperature should be exceeded. *American Motors Corp., Kelvinator Div., Detroit.*

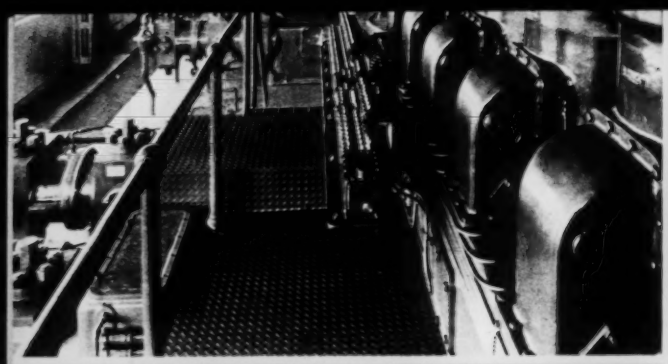
Materials Handling

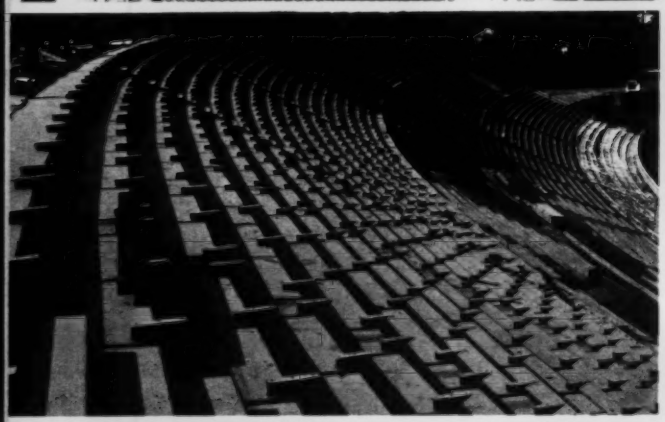
Hopper Feeder: Hopperal oscillating feeder provides automatic feeding of small production parts such as bolts, nuts, screws, nails and rivets. It arranges them selectively on an internal track, permitting them to move in an orderly manner to the outside feed track and down to any required position. Selector gate rejects pieces not properly positioned. Firmly supported by the hopper base, the outside track will permit long extensions to the work operation. The unit can be equipped with single or multiple tracks, and is self-powered. Tracks can be easily replaced with others to feed different items. Applications include assembly, inspection, gaging, packaging, processing, grinding, sorting and production loading. *Haberstump-Harris Inc., Detroit.*

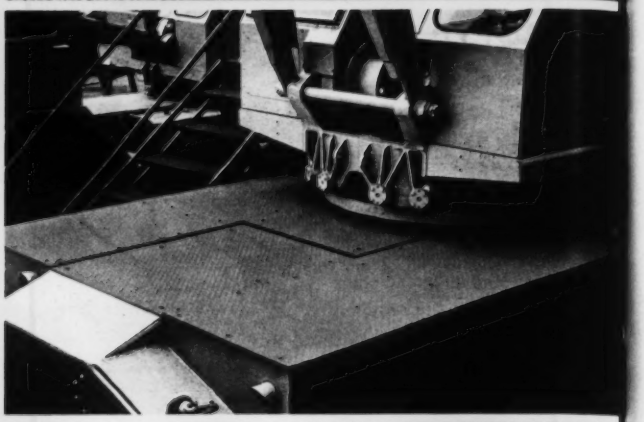
Fork Lift Truck: Model E Spacemaster has a high-pressure hydraulic system which permits fast, smooth lifting and lowering speeds. It contains an oil filter and cam-type piston pump. Redesigned mast has a new carriage and fork mount-

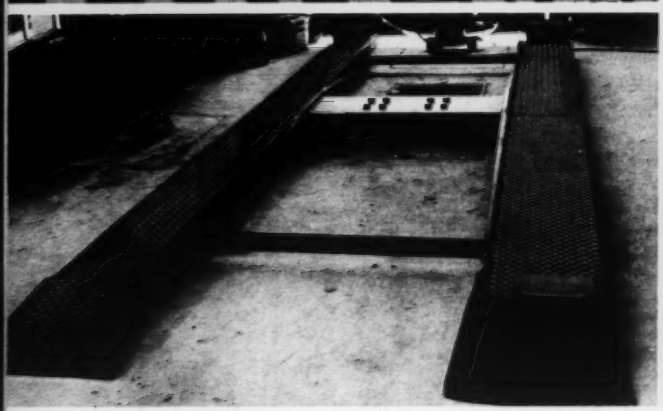
Circle 643 on page 19→

"THIS FLOORING MATERIAL HAS EVERYTHING." That's what users of Inland 4-WAY SAFETY PLATE say about this rugged, steel flooring material. No other material offers such a combination of advantages. For example, it's (A) STRONG and DURABLE. Not just a safety flooring surface material, but a steel plate that can be used as a structural member. (B) EASY TO KEEP CLEAN. Smooth, non-porous surface with no dirt traps. (C) FIRE RESISTANT. Can be used in applications where ordinary flooring is unsafe. (D) EASY TO FABRICATE. Is readily cut, sheared, punched, welded and formed with conventional equipment. (E) ATTRACTIVE. Pleasing over-all pattern design provides neat, modern appearance. (F) EASY TO APPLY. Lug design makes pieces easy to match. (G) SLIP-RESISTANT. Unique raised-lug pattern gives traction to feet and wheels. For more facts on using Inland 4-WAY SAFETY PLATE, please turn the page.









Manufacturers from coast to coast and in every type of business are discovering how versatile Inland 4-WAY SAFETY PLATE can answer their flooring problems in every case where safety, strength, fire resistance, long life and ease of maintenance are required. They're learning how surfaces covered with 4-WAY SAFETY PLATE pay off in saved man-hours, better fire protection, cleaner plants. They're finding that this same versatile material can add an important (and saleable!) safety feature to many of their products.

The next time you walk through your plant, keep your eyes open for places where rugged, economical Inland 4-WAY SAFETY PLATE can be put to work to help you increase the efficiency of your operation and the saleability of your products. Ask your steel distributor about 4-WAY!*

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ing to permit simple removal and adjustment of forks and attachments. Lifting height is 132 in. in capacities to 2000 lb and 130 in. in capacities from 2000 to 4000 lb. Collapsed height is 83 in. Control handles protrude upward within easy reach of the operator's right hand. The cab can be mounted from either side. All components are accessible for maintenance from the top of the truck. *Lewis-Shepard Products Inc., Watertown, Mass.*

Conveyor: Model 4000 elevating transfer conveyor transfers up to 12 in. long cylindrical parts with diameters from $\frac{3}{8}$ to $1\frac{1}{4}$ in. from one production machine to another. It accepts parts in a rolling position from the discharge chute of the first machine, elevates them and delivers them to the magazine of the next machine. The unit operates at a delivery rate adjusted to that of the second machine and is equipped with a bank control which shuts off the first machine if it feeds too fast. Power is furnished by a $\frac{1}{4}$-hp, 220/440-v motor through a variable speed drive. *Feedall Inc., Willoughby, O.*

Metalworking

Abrasive Belt Grinder: Two-level conveyor-type belt grinder is designed to grind both sides of ferrous and nonferrous metals, plastics, glass, ceramics and other materials in a single automatic cycle. Parts are carried under the upper grinding head on an abrasive conveyor belt, and automatically turned over in a gravity-feed hopper. Lower conveyor belt then carries them under the second head for grinding the reverse side. Speed of conveyor belts with $\frac{1}{2}$-hp conveyor drive is 2 to 25 fpm, with higher speed ranges available for special applications. The machine will not start unless the belt is tensioned. Control panels include tension safety light and conveyor reversing switch. Size of abrasive belts is 10 x 92 in., and belt speed is 5500 sfpm. *Engelberg Huller Co., Syracuse, N. Y.*

Lapping Machine: Lapmaster 36-in. model has been added to a line of lapping machines ranging in lap

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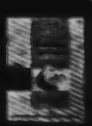

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Circle 644 on page 19

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Circle 645 on page 19

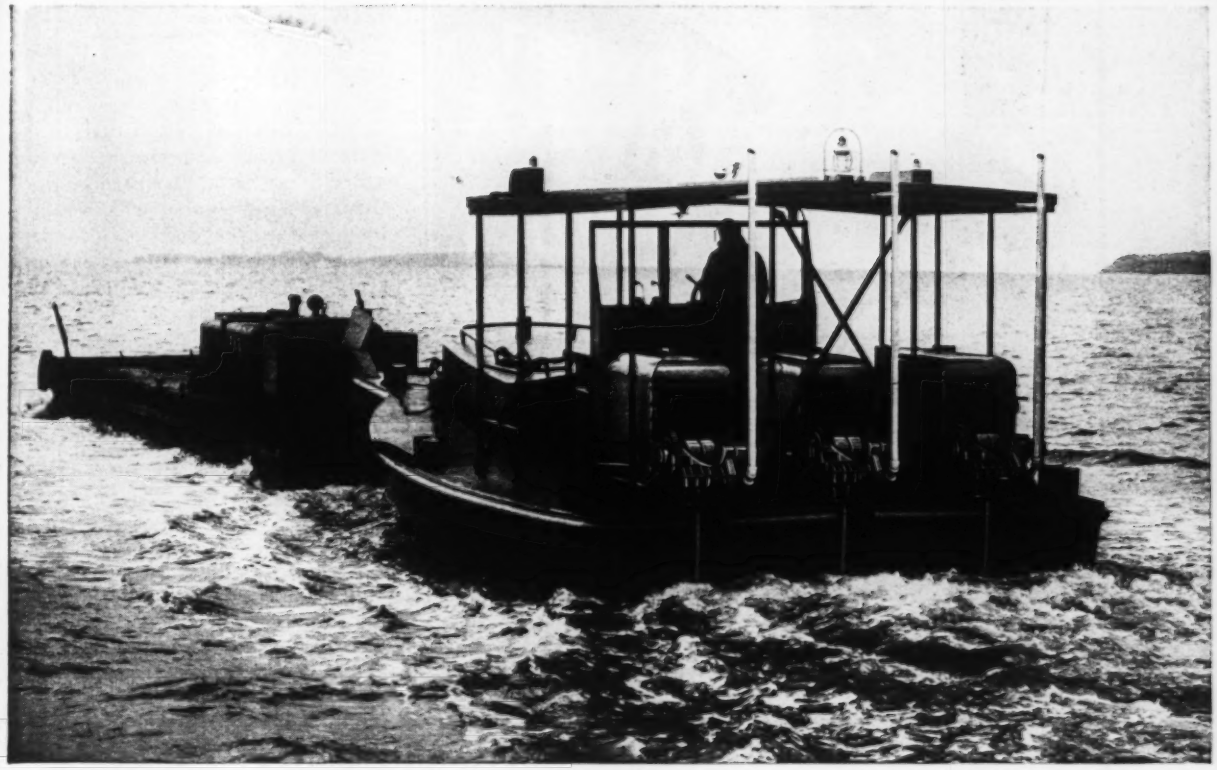
New Machines

plate diameter from 12 to 72 in. Inside diameter of the conditioning rings is 14½ in., thus permitting handling of parts up to twice that size. Drain hole is on the side of the unit, and a wiper blade is fastened to the underside of the base table to bring all of the spent compound into the drain. Fork-style agitator is placed at a 30-deg angle in the agitator tank to facilitate mixing of abrasive when left loaded in the tank for a long period. The machine generates surface flatness to less than one light band and finishes to 2 rms. Uses include lapping parts used in adding machines, engines, transmissions, cameras, tool and die equipment, and quartz and germanium crystals. Materials accommodated include monel, steel, stellite, brass, aluminum, glass, carbon, plastics and ceramics. *Crane Packing Co., Morton Grove, Ill.*

Cold Heading Machine: Headmaster solid die, double-stroke cold-heading machine has production rates ranging from 300 to 450 screw or rivet blanks per minute. It heads rivets up to ⅛ x ¾, machine screws up to #6 x ¾ and sheet metal screws up to #8 x ¾. Design incorporates horizontal shifting punches, toggle-actuated gate mounted on rods, friction roll feed, individually adjustable punch holders, cam-operated shifter and cut-off, magnetic brake, shafts mounted in roller bearings, centralized lubrication system and variable-speed drive. Toggle-actuated gate mechanism provides two blows, one long stroke and one short stroke, for each flywheel revolution. The gate advances rapidly and then decelerates on contact with the blank, producing a squeezing action rather than an abrupt blow. *Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.*

Processing

Hardening Furnace: Radiant tube, clean hardening furnace performs clean hardening, annealing, carburizing and other atmosphere work. The unit has vertical alloy radiant tubes which are easily replaced from the top of the fur-



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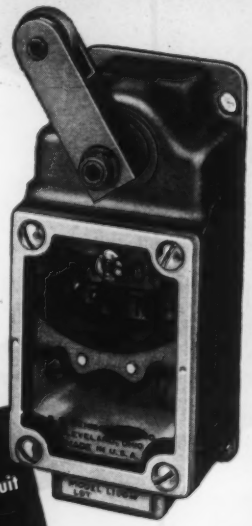

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Typical 'Bounce'—milliseconds	4	16	4
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Circle 647 on page 19

New Machines

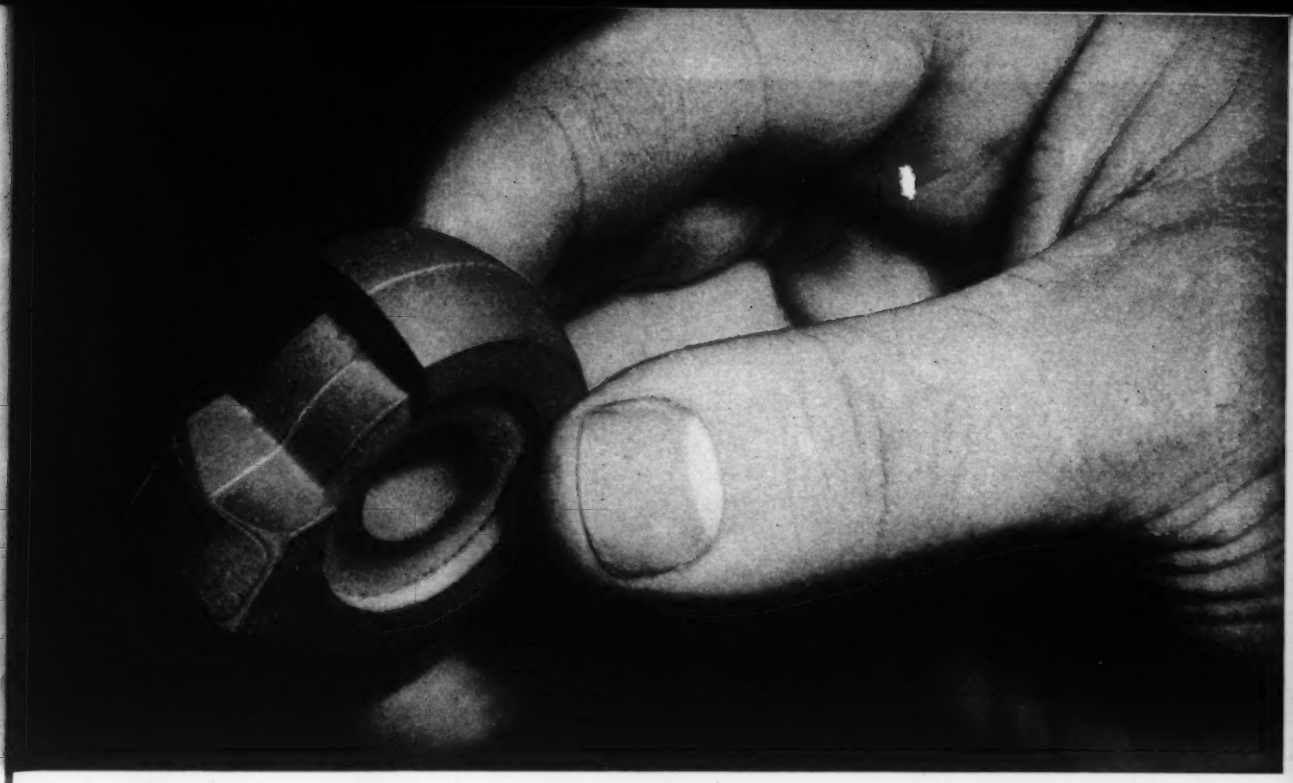
nace. A high-velecity alloy fan, for recirculating the atmosphere, is located in the roof of the unit. The door is raised and lowered from a drive located at the base of the furnace. Fully sealed with asbestos gaskets, the door is also inclined to provide a natural friction seal. A gas curtain is provided, and its operation is automatic upon opening the door. A silicon carbide hearth is provided for large workpieces; if smaller parts are to be placed in baskets, alloy roller rails are available. *Standard Fuel Engineering Co., Detroit.*

Aluminizer: Model CRS-48 aluminizer, originally designed for high vacuum coating of television tubes, incorporates all devices required for fully automatic or manual aluminizing of cathode ray tubes up to 27 in., and can be readily adapted for processing all types of tubes and bulbs. Complete coating cycle on a 21-in. television tube is less than 6 minutes. The unit is totally enclosed in a console-type steel cabinet fitted with drawer-type control panel. Power supply is 115 v, single phase, 60 cycle. *New York Air Brake Co., Kinney Mfg. Div., Boston.*

Plastic Forming Machine: Vac-Trim Model 246 performs vacuum forming, drape forming, plug forming and trimming of thermoplastic sheets. It performs straight vacuum forming using female molds, drape forming using male molds, and plug forming using plugs and female molds. Formed parts are trimmed by the use of temperature-controlled heated trimming dies. Control is manual or automatic. Maximum sheet size is 24 x 24 in. *Vacuum Forming Corp., Port Washington, N. Y.*

Testing and Inspection

Compression Tester: Super L compression testing machine with 500,000-lb capacity is designed so that any one of three testing ranges—full capacity, 1/5 capacity and 1/20 capacity — is instantly available without stopping the test. Load is indicated electronically on a 28-in. illuminated dial. Piston and cylinder can be installed in a pit so that the compression table



How precision casting cut costs 84%

on this small part

Camco, Inc., of Houston, Texas, specializes in oil field equipment.

One of their products is a retrievable gas lift valve which can be installed in, or removed from, an oil well without pulling the tubing.

Inside the valve is a very important part, the latching cam, which locks the valve in place.

And that little part caused Camco expense and trouble — until they came to Inco.

The part had to be corrosion-resistant to resist oil well corrosives — it had to be strong to take the pressures — it had to be hard so that it wouldn't gall, seize or change shape despite years of exposure to corrosion, abrasion, shock and pull.

One metal they tried was hard enough but it proved too brittle. And costs to machine the part from bar stock seemed out of line.

Camco, already using Inco Nickel Alloys — Monel® and "K"® Monel — for other parts of the valve with good results, decided to consult Inco on this one.

After experimenting, Inco engineers recommended precision investment castings in "S"® Monel.

The price of the finished cam, including the cost of drilling and lapping, cut Camco's cost on this part 84 per cent!

Maybe this is the sort of thing that can happen to you.

* * *

Can You Cut Costs with Inco Precision Castings?

Whenever you have a part which is 6 inches x 5 inches or smaller, weighs under 3 lbs., requires starting tolerances as close as plus or minus .005 inch per linear inch, and needs 5 or more fabrication steps, there's a good chance you can save by having it precision cast.

What Alloys Can Be Precision Cast?

You may obtain precision castings from Inco in many metals and alloys, from plain carbon steel to the new super alloys. And no matter what metal you specify, you get many advantages.

Seven Advantages of Precision Casting

Precision castings may save as much as 60 per cent of production costs. (Savings like Camco's are unusually high.) They also make possible the use of extremely hard metals. Reduce machine shop bottlenecks. Lead to economies through redesign. Reduce metal scrap. Often permit the use of a higher alloy which otherwise would be too costly. Even make possible designs you previously thought impractical to produce.

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Trying to keep costs in line on some small part? Then write for new 16-page booklet, "Cast to Outlast." Contains many case histories detailing how others cut costs with Inco precision castings. There is a good chance this helpful data will suggest a practical way to cut your costs, too.

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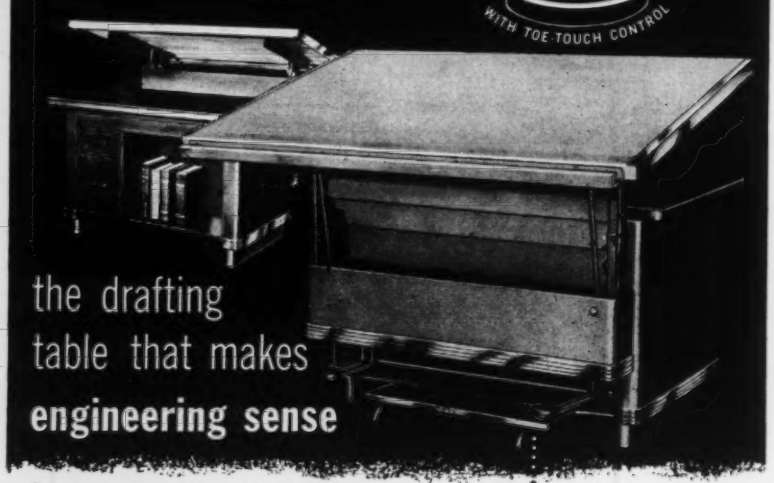

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Circle 648 on page 19

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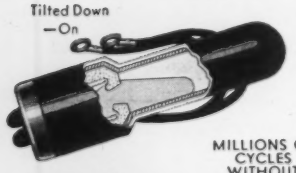
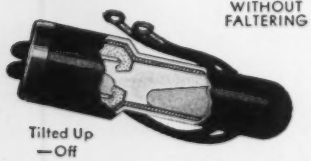


MILLIONS OF CYCLES WITHOUT FALTERING



This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

See telephone directory for local distributor, or write.

DURAKOOL, INC.

ELKHART, INDIANA, U.S.A.---700 WESTON RD., TORONTO 9, CANADA

Durakool ALL-STEEL MERCURY *Switches*

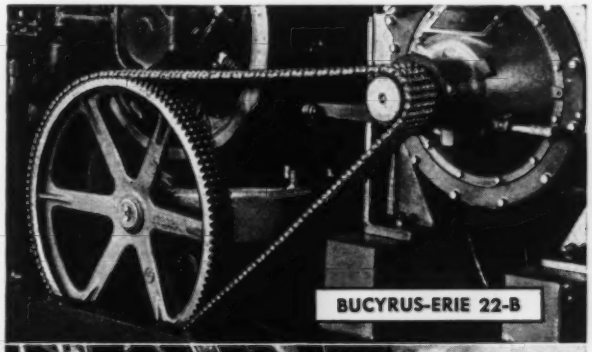
Circle 649 on page 19

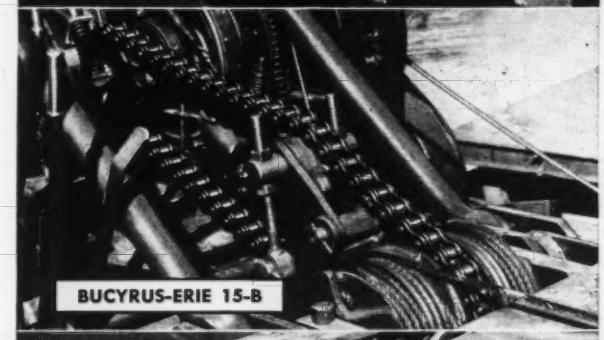
New Machines

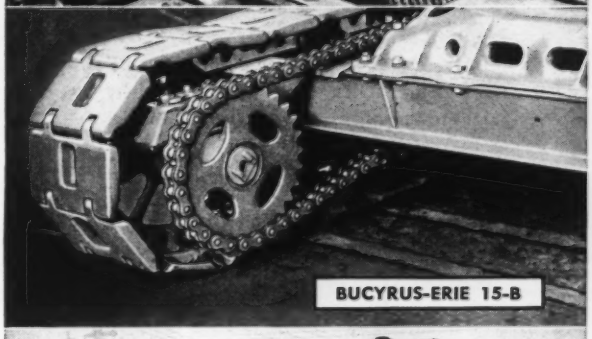
is at floor level within easy reach of the operator. Height of the motor-controlled upper crosshead is quickly and easily adjusted by pushing a button on the control and indicating cabinet, separate from the loader. *Tinius Olsen Testing Machine Co., Willow Grove, Pa.*

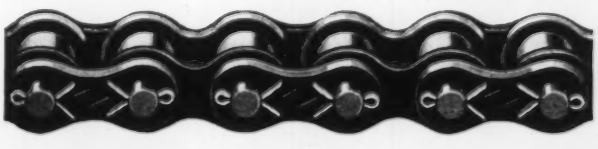
Vibration Shakers: Models 177 and 174 wide-band shakers are designed for high frequency operations and low input requirements in systems for the random vibration testing of components and assemblies. All secondary structural resonances have been eliminated so that the armature behaves as a simple single - degree - of - freedom system over an extended frequency range. Inherent rigidity of the armature maintains a high first resonance under loaded conditions. Model 174 shaker armature has its longitudinal resonance at approximately 4000 cps, bare table. Model 177 armature first resonance is approximately 3000 cps. bare table. Model 174 tests components weighing up to 30 lb and has a force output of 1500 lb. Force rating of Model 177 is 5000 lb *Calidyne Co., Winchester, Mass.*

Bending Press: Testing machine for making cold bending tests quickly under loads up to 150,000 lb accommodates low carbon steel bars up to 2 in. square or 2 in. in diameter in lengths from 5 to 24 in. It also accommodates flats up to 4 in. wide and 1 in. thick in the same lengths. The machine is hydraulically operated at controllable table speeds of 1½ or less to 10 in. per minute. Maximum upward stroke is 11 in. Loads are measured by an Emery bourdon-tube indicating system with 12-in. diameter dial graduated in 500-lb divisions. Sliding platens can be used quickly after making a V bend with rollers, to bend specimens 180 deg or flat on themselves. Overloads are prevented by limit switches and overload pressure relief valve. Three pairs of support rollers, 6, 5½ and 5 in. in diameter, are furnished. Bending pins ranging from 3/32 to 8.46 in. in diameter are provided with the machine. *Baldwin-Lima-Hamilton Corp., Philadelphia.*









FOR POWER TAKE-OFF...

CROWDING...

AND CRAWLING

Uniform Highest Quality Diamond Roller Chains provide Greater Dependability, Longer Life, More Economy

Diamond Roller Chains are used on many leading makes of earth moving and materials handling equipment because they provide outstanding service on vital power drives. Their *uniform* highest quality is the greatest possible assurance of trouble-free performance essential to profitable operation of every machine.

The many advantages of Diamond Roller Chains: flexibility, light weight, great strength, wide adaptability for high or low speed drives can solve your transmission problems. Diamond Engineers are available to assist you.

DIAMOND CHAIN COMPANY, Inc.

Where High Quality is Traditional

Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana

Offices and Distributors in All Principal Cities

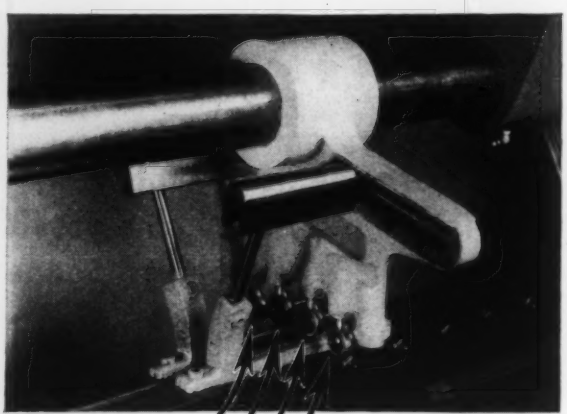
DIAMOND ROLLER CHAINS

THE SURPRISINGLY VERSATILE

HEIM Unibal

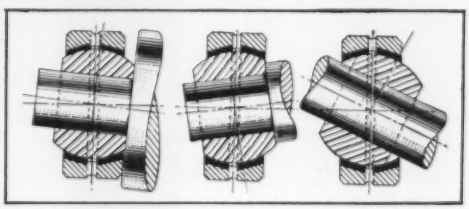
Suspension Hangers . . . right out of stock!

Because of the very name of the piece, we think of a "rod end" as a sort of universal joint at the end of a rod when used in a linkage mechanism for pull-push operation. And for transmitting motion at varying angles, the Heim Unibal Rod End is the most dependable and most efficient of all.



However . . .

the ability of the Heim Unibal to correct misalignment in any direction, the smoothness of its oscillation, and its low cost, are just the qualities looked for in some unusual shaft supports.



HEIM MALE ROD END

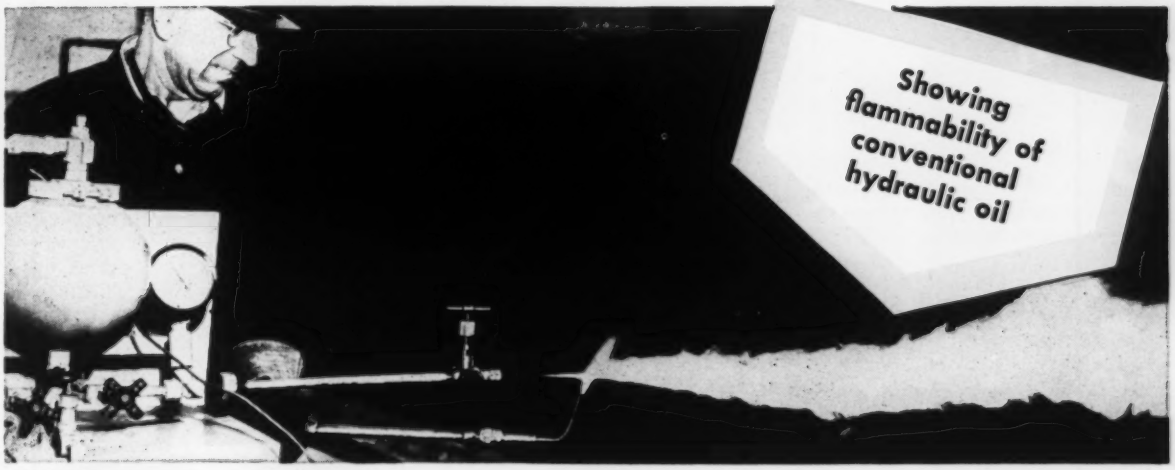
Take this Kidde Knitter as an example of how Heim Unibal Rod Ends have been used as suspension hangers for the guide bars. It is essential that these bars move laterally, both smoothly and freely.

The hanger arm is drilled and tapped, and the male Heim Rod End is screwed into place. Assembly is simple, yet alignment of the bars is positive, and vertical adjustments can be made quickly and easily.

Perhaps you have a place where Heim Rod Ends can improve mechanical function and cut the cost of parts and assembly. Submit your problem to the HEIM engineering department for advice and assistance.

THE HEIM COMPANY | FAIRFIELD, CONNECTICUT

HAS MANY USES OTHER THAN STRICTLY ROD END APPLICATIONS



Flame tests prove its fire-snuffing ability

SHELL
IRUS
FLUID 902

Entirely new formula: Shell Irus Fluid 902 is a special formulation . . . product of three years' development and field testing. It is suitable for nearly all industrial hydraulic systems, as a direct replacement for presently used oils. *Here is a fire-resistant hydraulic fluid that can be widely used.*

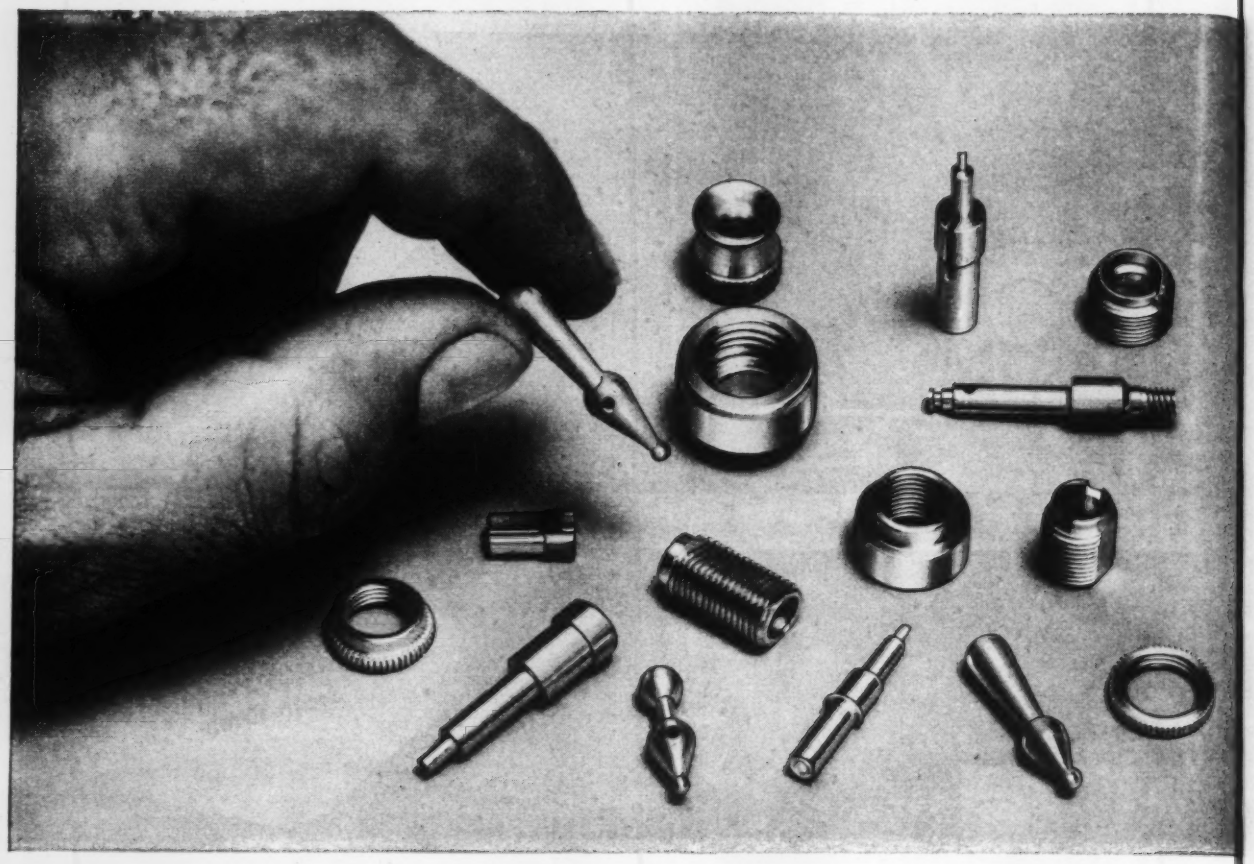
Non-corrosive: Shell Irus Fluid 902 contains no corrosive ingredients. It has no harmful effects on seals, fittings or bearings. It does not promote rust.

No major modification necessary . . . simply clean present fluid thoroughly out of system and replace directly with Shell Irus Fluid 902. You can use it with complete confidence. Write for test data and all information.

SHELL OIL COMPANY

50 WEST 50TH STREET, NEW YORK 20, NEW YORK
100 BUSH STREET, SAN FRANCISCO 6, CALIFORNIA

Circle 652 on page 19



Typical parts made of Alcoa Aluminum Screw Machine Stock by Enterprise Mfg. Co.

HOW PFLUEGER* MAKES MORE AND BETTER REELS WITH ALCOA® ALUMINUM SCREW MACHINE STOCK

Since Civil War days, 3 generations of Pfluegers have parlayed a small harness business into the giant Enterprise Manufacturing Company of Akron, Ohio . . . one of the world's foremost makers of fishing tackle. Alcoa Aluminum Screw Machine Stock has contributed to the sales appeal of Pflueger reels since 1929.

The Pflueger success story is typical of the competitive advantages frequently gained by a switch to aluminum screw machine stock. Its free-machining qualities speed production by permitting operations at maximum spindle speeds . . . with less tool breakage, fewer rejects, better finish with fewer secondary operations. It has longer tool life, provides three times as many parts per pound of metal. And abundant supplies are available.

All these solid economic advantages point up the wisdom of a hard commercial look at aluminum screw machine stock. Alcoa will provide you with technical assistance, alloys information, and the greatest store of experienced counsel available in the industry. Just call your nearby Alcoa sales office, listed under "Aluminum" in your phone book. Aluminum Company of America, 873-J Alcoa Building, Pittsburgh 19, Pennsylvania.

IN PURCHASING

Wayne Miller, Director of Purchasing, says,

"Pflueger reels have used aluminum parts since 1929 . . . and we've always bought our metal from Alcoa. Alcoa's personnel have always been most cooperative. Their shipping dates and promises always hit together. We especially like the shipping notices Alcoa forwards to us. Tolerances and composition always meet our most exacting specifications. Engineering help and warehouse service continue to keep us happy."

IN DESIGN

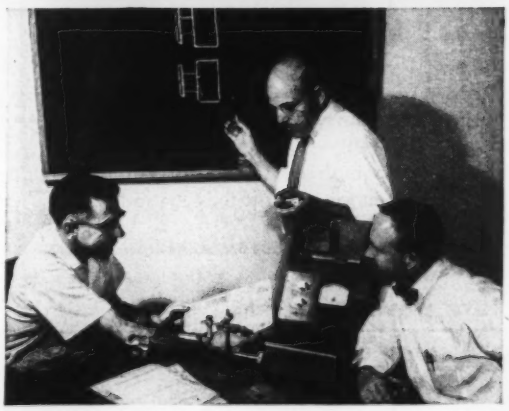
Mr. Tom Sarah, Chief Engineer of Design and Development, says,

"Our annual sales conference guides design policy. Customers began to insist on lightness; we were given the job of lightening up while still maintaining quality and dependability. Aluminum looked like a natural . . . and was. It takes the high-quality finish we require. It offers the corrosion resistance so essential when our reels are used in salt-water fishing. And Alcoa's research and development facilities were a great help to us in selecting proper alloys and finishes. We will be using more and more aluminum parts."

IN PRODUCTION

Garnett Young, Foreman, in discussing production with operator John Schmidt (left), says,

"Many of our workers are women and aluminum's light weight eases our materials handling. We get longer tool life and can hold closer tolerances on operations such as drilling, milling, tapping and machining. We cut fine-pitch threads and we prefer aluminum for this more than any other metal. Because aluminum is easier on tools, we get less heat and can use lighter oils. With aluminum, we have no trouble with concentricity. We run at top spindle speeds. There's less chip trouble and we get high prices for our scrap. If trouble develops, Alcoa sends engineering help to straighten us out in a hurry."



IN OUTSIDE SUPPLY

Some parts of the famous Pflueger reels are made by Locke Machine Company of Cleveland, Ohio. (Member of the National Screw Machine Products Association.) Here Mr. A. W. Glasheen, Estimator; Mr. J. E. Tomer, Vice President and Mr. E. H. Baker, Factory Manager, discuss the finish requirements of a Pflueger reel. They say, "Pflueger demands tight tolerances and a superfine surface finish. We find it easy to comply by using Alcoa Aluminum Screw Machine Stock. Tool life is good and we use extremely heavy machine feeds. Concentricity requirements are close, but we maintain them with aluminum. Our operators like to work with aluminum and we like to deal with Alcoa. Service has been extremely prompt, and their quality is excellent. We feel it is the best on the market. We have never had to reject Alcoa Screw Machine Stock.

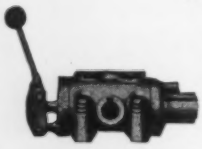
THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM

"Why is it easy to plan Hydraulic Circuits using RIVETT VALVES?"

COMPLETE LINE



Hand, Foot, Cam, Solenoid, Pilot Operated

Sub-Plate Mounted, Solenoid, Pilot Operated

Flow Control, Check, Decoleration, Relief, Unloading, Sequence, Counter-Balance

1500-3000 P.S.I. | PISTON DESIGNS FOR ANY CIRCUIT

Sizes: 1/4", 3/8", 1/2", 3/4", 1", 1-1/4", 1-1/2"

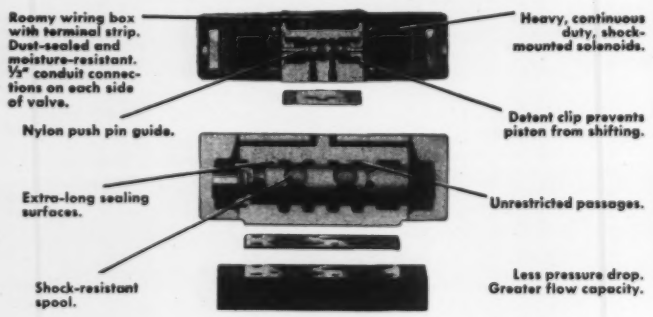
Actions: Standard, Spring Return, Spring Centered, Ball Detent

"1st — Rivett's 190 standard models give me more latitude in engineering a circuit. This wide selection permits choosing the right type of valve for a more economical and efficient operation."

EXPERIENCED DISTRIBUTORS

"2nd — My Rivett Distributor is experienced in hydraulic design. With his help I have been able to plan better operating systems."

QUALITY CONSTRUCTION


Roomy wiring box with terminal strip. Dust-sealed and moisture-resistant. ½" conduit connections on each side of valve.
Heavy, continuous duty, shock-mounted solenoids.
Nylon push pin guide.
Detent clip prevents piston from shifting.
Extra-long sealing surfaces.
Unrestricted passages.
Shock-resistant spool.
Less pressure drop. Greater flow capacity.

Sub-Plate Mounted, Solenoid, Pilot Operated Valve

"3rd — I can count on longer life as well as the rated performance of Rivett Valves. They are designed and built for accurate circuit control."

INFORMATIVE LITERATURE

"4th — Rivett valve catalogs are complete with specifications and drawings. Write for #204 and #260."

RIVETT LATHE & GRINDER, INC., DEPT. MD-9 BRIGHTON 35, BOSTON, MASSACHUSETTS

RIVETT furnishes a complete power package

AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS

Member—National Fluid Power Association

Circle 654 on page 19

TRUCKING . . . Vital Transportation Link

Transmission Repairs only .0003c (3/10 mill) per mile at SUPER SERVICE

after an average of 210,176 miles on each of 172 Fuller Transmissions

"With the Fuller ROADRANGERS in our fleet, we've hit an all-time low in transmission repair costs," says Ray Carter, Director of Engineering for Super Service Motor Freight Co., Nashville, Tennessee.

Super Service recently completed a careful check of maintenance records for 172 White tractors equipped with Fuller 10-speed Semi-Automatic ROADRANGER Transmissions. With an average of 210,176 miles per tractor, company records showed a remarkable average repair cost of *only .0003c (3/10 of a mill) per mile for each* ROADRANGER *Transmission!*

About two years ago, Super Service standardized its entire over-the-road fleet on White tractors equipped with ROADRANGER Transmissions and Cummins diesel engines. From that time on, old performance records began to fall.

Operating from the South to the East . . . with terminals from Nashville to New York . . . the ROADRANGER equipped tractors pull square nose, 35-foot aluminum trailers that average 52,500 lbs. gross tare weight. The tractors now cut a full hour off the old 10-hour trip time on the Nashville-East run . . . taking rugged Tennessee hills at 35 miles an hour when 15 was considered a good speed with the old equipment.

Super Service cuts running time and maintenance to a minimum by running its rigs straight through from Nashville to New York. Drivers are changed twice . . . but there's no need to warm up a cold engine at each stage of the relay.

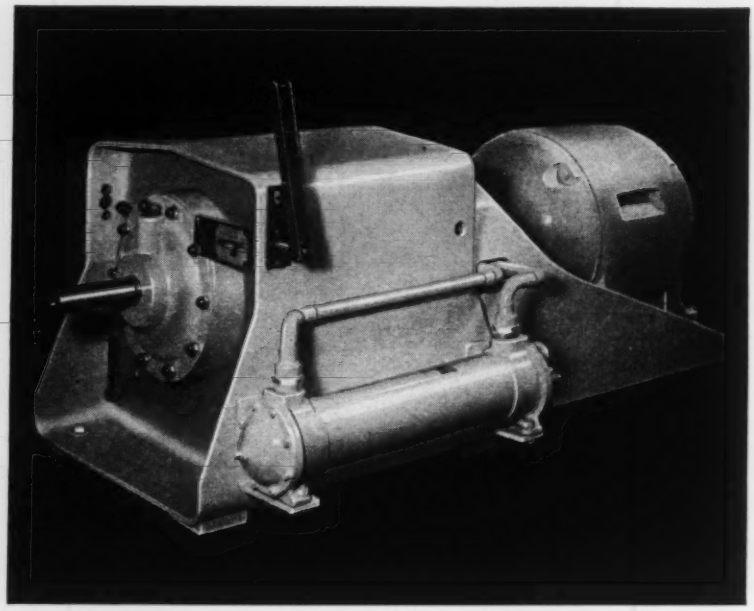
For your fleet, get the facts on ROADRANGERS from your truck manufacturer or truck dealer now.

FULLER MANUFACTURING COMPANY
TRANSMISSION DIVISION • KALAMAZOO, MICH.

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.

Circle 655 on page 19

Gýrol® Fluid Drives limit torque to give you a built-in safety factor!



Type VS, Class 2 Gýrol Fluid Drive is available in ten sizes, 1 hp to 800 hp, speeds to 3600 rpm.

The American Blower Type VS, Class 2 Gýrol Fluid Drive not only offers adjustable, stepless speed control, but its inherent shock - absorption ability protects machinery.

For, a Gýrol Fluid Drive will limit the amount of torque which can be transmitted under overload conditions. This torque-limiting capacity can be adjusted by merely positioning the speed-control lever.

What's more, Fluid Drive permits the motor to come up to speed under almost no-load conditions—allowing simplification of motors and starting equipment for heavy starting loads.

You'll discover many more important benefits for a wide variety of industrial applications by calling our nearest branch.

FEATURES

- Can be reversed while in motion by reversing motor
- Across-the-line starting on many applications
- Motor can reach full speed before engaging load
- A compact, self-contained unit
- Trigger-action response — adjustable speed
- Speed may be controlled manually or automatically

Speed control for the paper and textile industries

Papermaking and processing machinery needs smooth starting to prevent tearing; adjustable speed to adjust machinery to humidity, paper thickness; no-load starting to keep power requirements down. Fluid Drive is the practical answer. It meets these problems easily — and without excessive maintenance. In the same manner, textile machinery needs accurate speed control to give maximum production rates within safe limits for the yarn. Again the answer is Gýrol Fluid Drive. Consult our nearest branch office or write us for information.

American Blower products serve industry

- AIR CONDITIONING, HEATING, VENTILATING EQUIPMENT
- MECHANICAL DRAFT EQUIPMENT
- INDUSTRIAL FANS AND BLOWERS
- CENTRIFUGAL COMPRESSORS
- GYROL FLUID DRIVES
- DUST COLLECTORS
- REFRIGERATING MACHINES

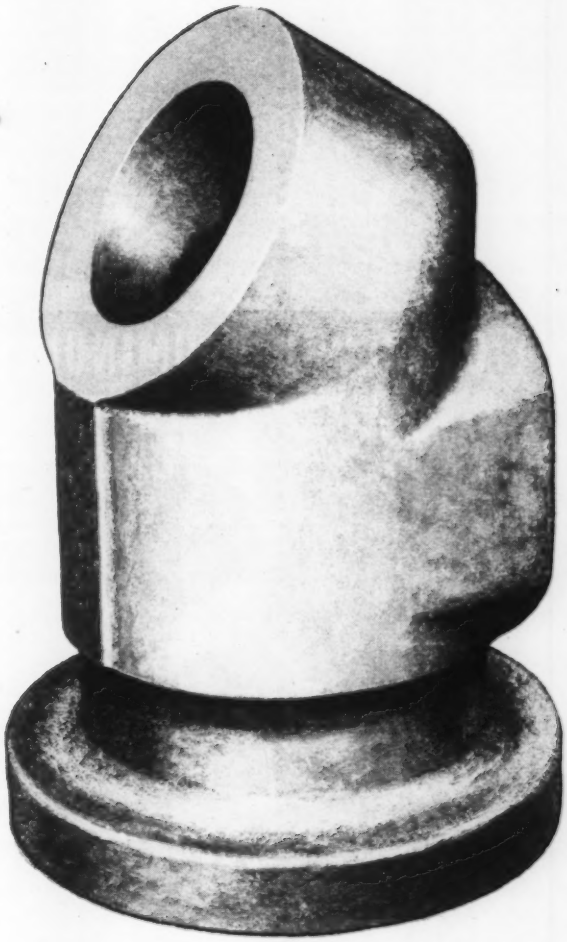
AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of American-Standard

AMERICAN **BLOWER**

2,370 lb.

FERROUS

FORGING



CAMERON'S SPLIT-DIE FORGING PROCESS

makes possible a saving in machining time plus a better grain structure in this launching valve body. High quality alloy steel press-forgings with both internal and external contours are produced by Cameron in a great variety of sizes and shapes.

Weight in these forgings is from 200 to 5,000 lbs. but design possibilities of surface and mass have made such a break with past practice that often we are asked, "Is this a forging?"

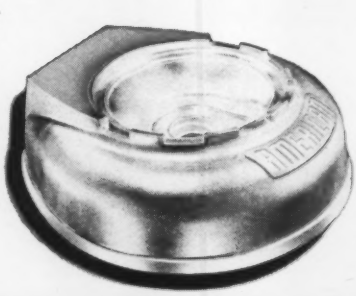
For information about the unusual advantages of these unusual forgings, write or call . . . .

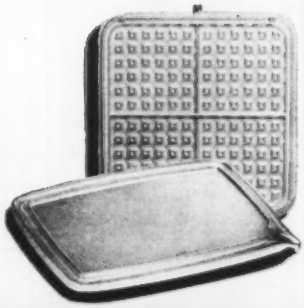
Cameron

IRON WORKS, Inc.

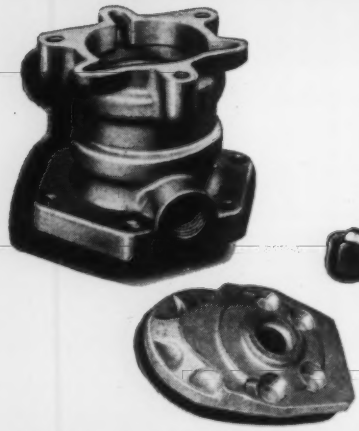
SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

Circle 657 on page 19

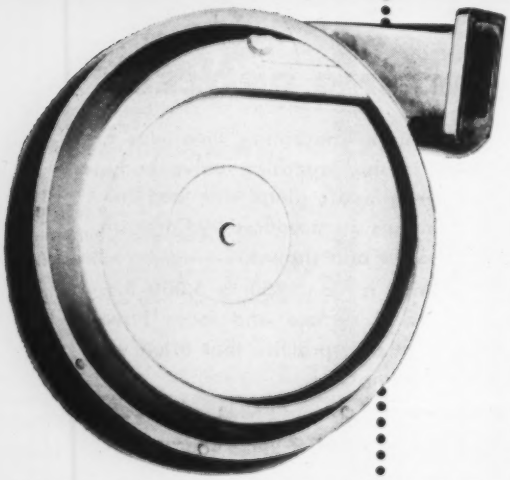




DON'T OVERLOOK ALUMINUM PERMANENT MOLD FOR



MORE CASTING VALUE PER DOLLAR



New production techniques and finishing services have doubled the use of aluminum permanent mold castings during the past three years.

Monarch's continuous-melt furnaces and new finishes, such as Velvaglaze® and Spectraglaze, are examples of Monarch-pioneered methods for mass-producing quality aluminum permanent mold castings. These castings offer superior strength, metal structure and finishing qualities.

Monarch's progress has been accomplished in conjunction with the steady expansion of our proven die casting operations. Monarch's "non-competitive" experience in both casting methods will give you the right answer for mass-producing your product at the lowest end-cost.

SINCE 1913
MONARCH
ALUMINUM
PIONEERS IN CASTING PROGRESS

Velvaglaze, Spectraglaze and Monarcast are Trade Marks of

MONARCH ALUMINUM MFG. COMPANY—9205 DETROIT AVENUE—CLEVELAND 2, OHIO—OLympic 1-1700

MANUFACTURERS OF: *Aluminum Permanent Mold Castings • Zinc Die Castings • Aluminum Die Castings • Exclusive Velvaglaze Finishing • and Spectraglaze, colorful Porcelain Enamel on Aluminum Permanent Mold Castings.*

Circle 658 on page 19

HALF A MILLION

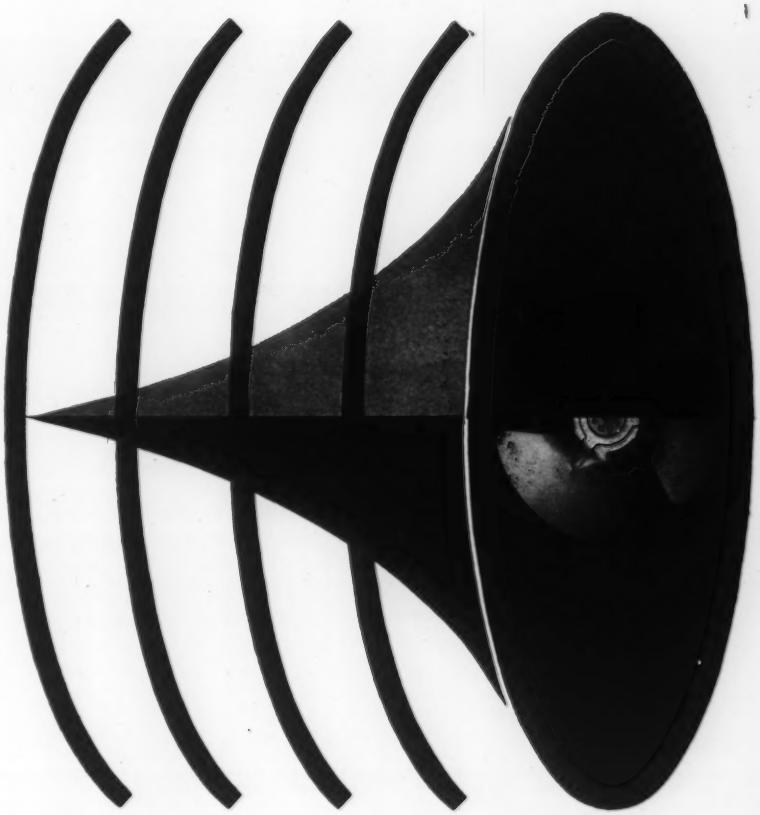
'VARIATIONS ON A THEME'

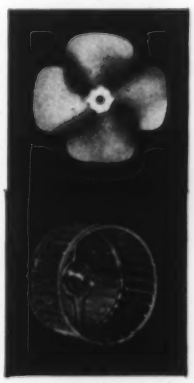
Industry writes the score—to the tune of nearly four billion dollars worth of products a year using Torrington air-impellers.

The research and development necessary to meet this tremendous demand is responsible for upward of half a million design variations of Torrington products... nice music when you have a tough problem.

If you are a design or production engineer, our exclusive engineering laboratory facilities—and our product engineering experience—are directly available to you for the solution of air moving problems related to your products.

Simply write or call us, or your nearest Torrington representative.

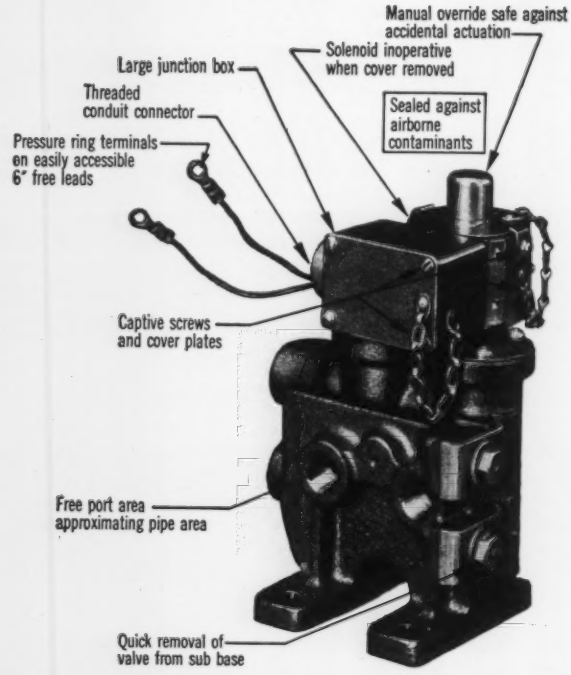




THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT
VAN NUYS, CALIFORNIA · OAKVILLE, ONTARIO

Circle 659 on page 19

XUM


Manual override safe against accidental actuation
Solenoid inoperative when cover removed
Large junction box
Threaded conduit connector
Sealed against airborne contaminants
Pressure ring terminals on easily accessible 6" free leads
Captive screws and cover plates
Free port area approximating pipe area
Quick removal of valve from sub base

For Machine Designers Who Want More Than Just 'JIC' Compliance, the Crescent® 4-Way Valve

®Product of Crescent Valve Company for the control of air, water and light oil to 150 P.S.I.

Pointed out on the photo above are the JIC features which are a must for many equipment manufacturers to gain acceptance of their machines in a growing number of production conscious plants. However, they offer obvious advantages even where they are not specifically demanded. Furthermore the JIC type Crescent solenoid is completely interchangeable with standard solenoids for the convenience of those manufacturers who want the JIC features available only for required application.

COMPETITIVE

With all its superior operating features the Crescent valve is probably the most competitively priced line on the market, particularly in the light of liberal trade and quantity discounts.

COMPACTNESS

Space, labor and materials savings have been pointed out to us by many equipment manufacturers as benefits from Crescent's compact design.

INTERCHANGEABILITY

Crescent valves can be converted to any practical current or voltage AC or DC by a simple coil change.

NO COIL BURNOUT

Short stroke, pilot operation and a generous power margin prevent overheating, overloading and the resultant coil burnout.

Write for Catalog 6-C

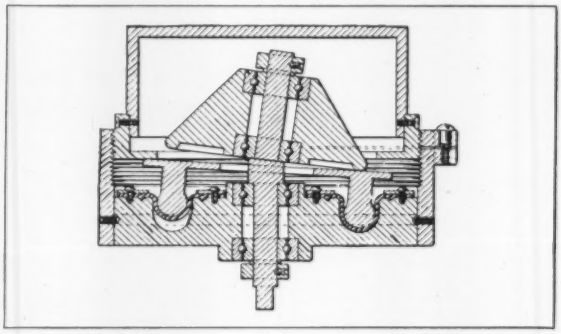
BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

NOTEWORTHY Patents

Variable-Displacement Pump

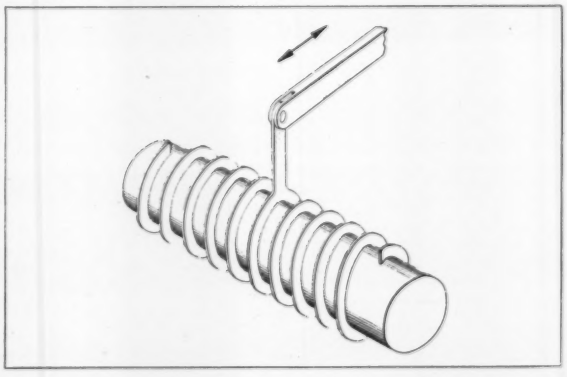
Output of this diaphragm-type positive-displacement pump can be varied from zero to maximum while the pump is running. Pumping action is developed when the flexible diaphragm is progressively



forced into the circular pump-body groove by the wobble action of the rotating cone and deflector plate. Displacement is varied by adjusting the position of the threaded stop ring which limits the vertical recovery motion of the diaphragm and deflector. Absence of metal-to-metal contact between parts exposed to the pumped liquid allows the unit to be employed in corrosive or abrasive media. *Patent* 2,752,852 *assigned to Standard Oil Co. by Elmer Bradley Offutt.*

Irreversible Control Mechanism

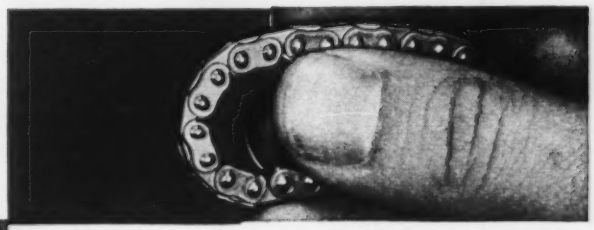
Mechanically coupled control systems are locked against load-induced reverse movements by a helical coil and drum mechanism. Adjustable as either a reversible or irreversible control element, the unit comprises a helical coil wound snugly around a fixed cylindrical drum. Normal input motion transferred by the coil to the output link arm is passed through

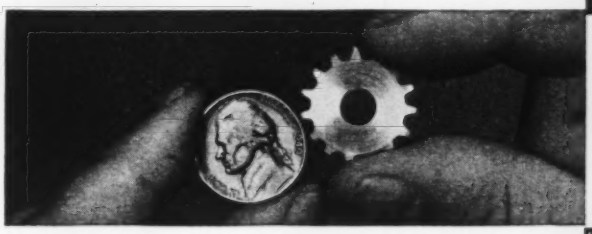


Circle 660 on page 19

Here's full-scale efficiency in a fractional hp drive

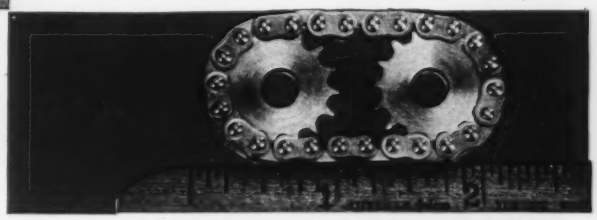
CHAIN AS SMALL AS THIS





SPROCKETS AS SMALL AS THIS

A COMPLETE DRIVE AS SMALL AS THIS



LINK-BELT 3/16-in. pitch Silent Chain is smooth, quiet, positive at high or low speeds

Here's the ideal drive for limited-space applications. Despite its pitch of only 3/16 inches . . . weight as little as .07 pounds per foot — this durable Link-Belt drive is better than 98% efficient. In fact, it often replaces expensive, precision-cut gear trains.

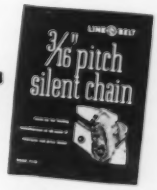
It's available in carbon and stainless steels . . . for ratios up to 12:1, speeds over 7500 rpm. Book 2510 explains outstanding features, including tooth and link form which eliminates chordal disturbance. Write for your copy to LINK-BELT COMPANY, Dept. 316, Prudential Plaza, Chicago 1, Illinois.

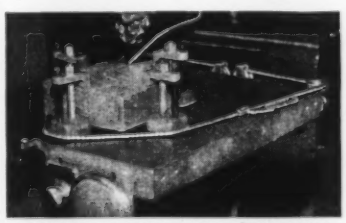
Link-Belt 3/16-in. pitch silent chain is installed as original equipment on

aircraft	portable planers
bread slicers	portable sanders
button making machines	radar equipment
cameras	recording machines
cigar making machines	rubber slicing machines
looms	sealing machines
meters	sewing machines
motion picture machines	timing devices
oil burners	typewriters
packaging machinery	vending machines

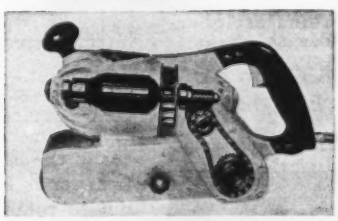
LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

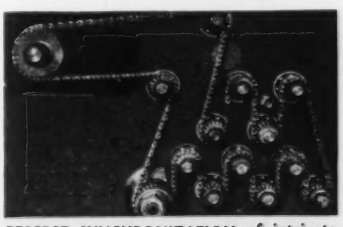




ACCURATE POWER FEED for contour shaping machine is assured by Link-Belt 3/16-in. Silverstreak silent chain.



POSITIVE POWER TRANSMISSION by Link-Belt 3/16-in. silent chain drive aids portable belt sander efficiency.

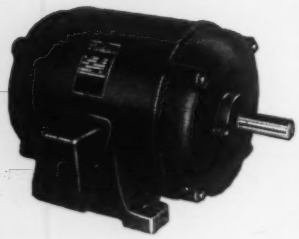


PERFECT SYNCHRONIZATION of intricate 14-wheel drive is maintained by Link-Belt 3/16-in. Duplex silent chain.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,251

XUM

NEW!
NEMA RERATED FRAME DESIGNS

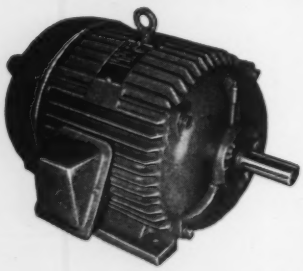


DRIP-PROOF (Open Type)

• Frame sizes from 56 thru 326. Cast-iron construction. Furnished with ball or sleeve bearings. All exterior surfaces are smooth and symmetrical. Streamlined design affords complete protection against dripping liquids or falling particles.

TOTALLY ENCLOSED NON-VENTILATED

• Totally enclosed, non-ventilated, from ½ to 3 HP. Recommended for use in non-explosive abrasive dust, metal dust, or where foreign matter may enter a motor. Positive protection of motor windings. Same design used with larger motors that drive propeller-type fans where the fan blows cooling air directly over the motor.



TOTALLY ENCLOSED FAN-COOLED

• Totally enclosed, fan-cooled, from ½ to 30 HP. Cooling air is drawn by an external fan across the motor towards the driven machine. Heat generated by the machine is not drawn across the motor. Same system used in standard, fan-cooled motors and explosion-proof designs.

Write for Bulletin SDA-155.

ELECTRIC MOTOR DIVISION
THE Peerless Electric COMPANY
FANS · BLOWERS · MOTORS · ELECTRONIC EQUIPMENT
1520 W. MARKET ST. • WARREN, OHIO

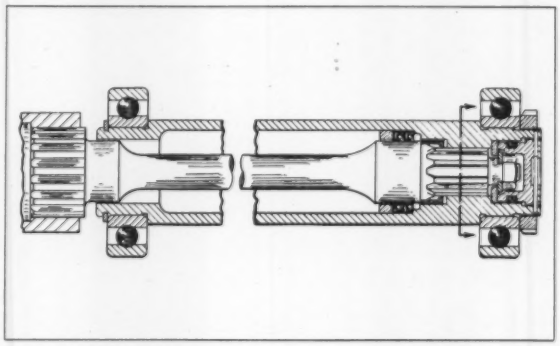
Circle 662 on page 19

Noteworthy Patents

without blockage when the free ends of the coil are partially unwound by auxiliary cams (not shown), allowing the coil to turn freely on the drum. Load-induced motion of the output link arm—initiated, for example, by flutter of aircraft control surfaces—winds up and tightens the coil on the fixed drum, effectively preventing movement of the control-system linkages. *Patent* 2,743,799 *assigned to Chase Aircraft Co. by Donald D. Maxson.*

Torsional Vibration Damper

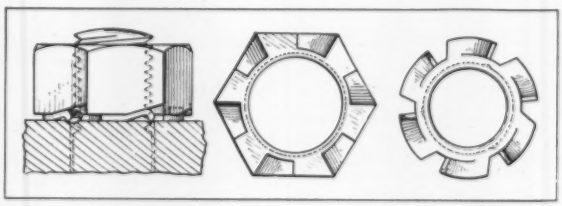
Resonant vibration of shaft-driven components, such as piston-engine accessories, is suppressed by a torsional vibration damper that provides either vis-



cous or velocity-type damping action. Cavities between loose-fitting spline teeth, connecting the outboard end of the quill shaft and the hollow accessory shaft, are filled with hydraulic damping fluid. Relative motion of these shafts, with resulting oscillation of the driven load, is damped out by the metering of the fluid through an orifice plate. Small torsional oscillations of the input at nonresonant frequencies are compensated by flexing of the quill shaft. *Patent* 2,738,660 *assigned to Jack & Heintz Inc. by Stewart E. Gail.*

Locknut

Multiple teeth stamped in the washer of a nut-lockwasher assembly are forced into close engagement with the workpiece by the cam action of recesses



cut in the lower face of the nut. Holding power of the fastener is thereby increased by any tendency of the nut to rotate relative to the washer. Shown here as applied to a standard hex nut, the locking device can also be applied to screw-type fasteners. *Patent* 2,754,872 *assigned to Illinois Tool Works by Ougljesa Jules Poupitch.*

Simple Arithmetic...
Type 302, Sheet Base Price 47.50 cents per lb.
Type 430, Sheet Base Price -36.75 cents per lb.
Saving 10.75 cents per lb.
in Stainless SHEET Costs!

Now you can SAVE $215 per ton in base price alone!

Many designers and fabricators who are currently using Type 302 stainless can, in numerous applications, specify Type 430 straight chromium stainless and take advantage of the 10¾ cents per pound difference in base price. Some of our customers are already saving more than $215 per ton using our 430 MicroRold stainless sheet.

The steel industry estimates that 50% of all stainless sheet applications could satisfactorily employ Type 430, the least expensive of all stainless grades, as an economical and practical material. When properly applied, Type 430 has all the desirable qualities of beauty, corrosion resistance, strength, long life and low maintenance that no other material, except stainless, can offer.

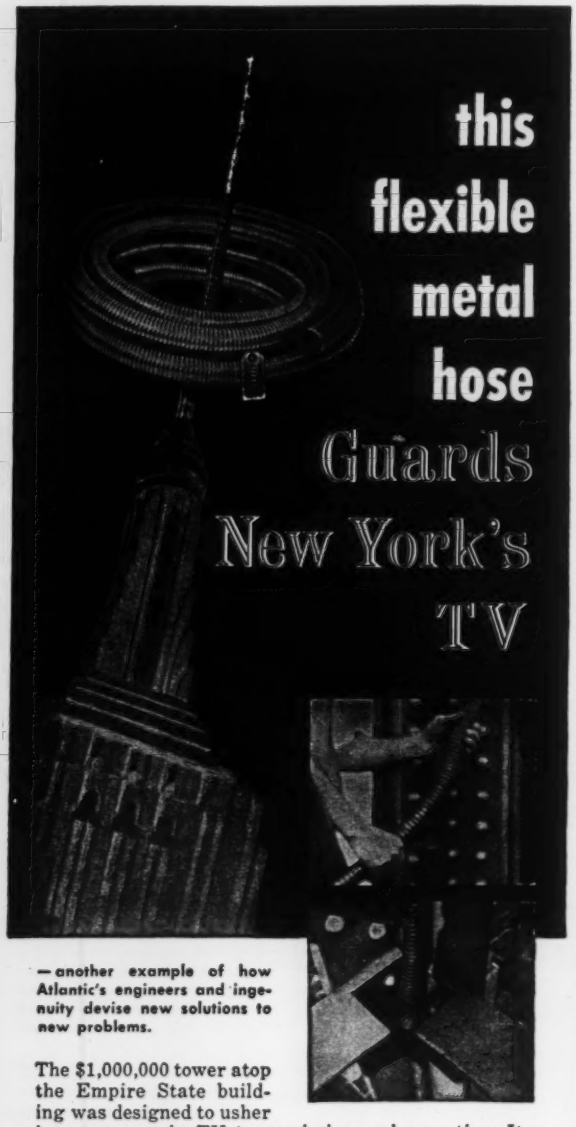
We are currently producing our MicroRold Type 430 sheets up to 48″ wide in thicknesses .005″ to .109″ with 2B or 2D finishes; and in thicknesses .010″ to .109″ in No. 3, 4 and 7 finishes.

Send for Your copy, "Care and Use of 430 MicroRold Stainless Steel"

Washington Steel *Corporation*

9-E WOODLAND AVENUE, WASHINGTON, PA.

this flexible metal hose Guards New York's TV



— another example of how Atlantic's engineers and ingenuity devise new solutions to new problems.

The $1,000,000 tower atop the Empire State building was designed to usher in a new era in TV transmission and reception. Its construction required an unprecedented number of circuits to travel up a tower often of less than two feet square. The conduit, enclosing the cables, had to be extremely *flexible* to avoid splice plates, rivet heads and diagonal braces in the steel work. It had to be permanently weather tight.

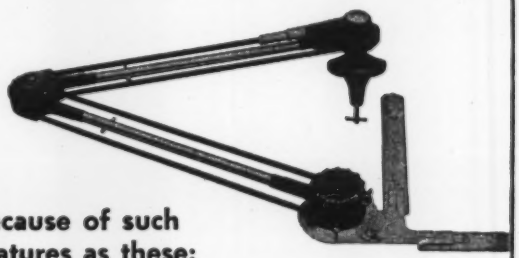
Ordinary rigid and flexible metal conduit failed! Atlantic's engineers in cooperation with the RCA Service Co. designed a heavy duty, high pressure bronze hose that did the job and also saved many costly and hazardous man hours of work. This hose was JOB TESTED and CERTIFIED.

Our engineers will help solve *your* problems in weather protection . . . flexibility . . . conveying . . . controlling pressure, movement and vibration . . . correcting misalignments. Seamless and Interlocking Hose. Bronze, Steel, Stainless Steel, Monel. ⅛"-36" I.D. with proper fittings. Write for Bulletin #500A See our Catalog in Sweet's Product Design File.

ATLANTIC METAL HOSE CO., Inc.
318 DYCKMAN STREET, NEW YORK 34, N.Y.

Circle 664 on page 19

Efficient engineering and drafting departments use VEMCO drafting machines



because of such features as these:

Automatic indexing for rapid settings.
Resilient scale chucks to insure firm grip.
Flexible, for speedy free movement.
VEMCO Versatilt provides easy floating motion on tilted boards.

VEMCO

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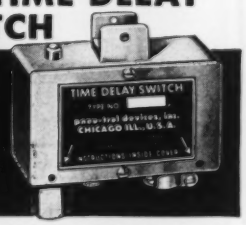
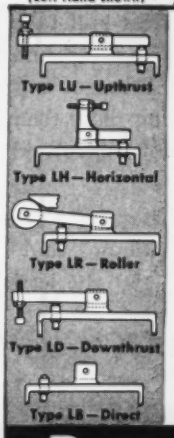
Circle 665 on page 19

Pneu-Trol TIME DELAY CONTROL SWITCH

. . . Gives Cylinder Applications Greater Efficiency Accuracy . . . Wider Use!



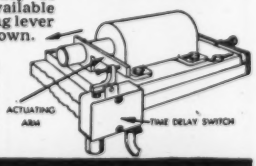
For any type actuation Left or Right Hand. (Left Hand shown)



- **Holds Cylinder dwell accurately to fraction of second.**
- **Automatically re-sets.**
- **Simple, Compact, Rugged.**

You can hold any motion or operation controlled or actuated by air or hydraulic cylinders at a positive stop on either end of the stroke for ¼ to 60 seconds in 20 to 1 ratios with Pneu-Trol Time Delay Control Switches. Simple in design with positive hydraulic timing action . . . compact and easily mounted on the machine or fixture, Pneu-Trol Switches are providing millions of trouble-free actuations in solenoid-operated cylinder applications of every type. Positive, controlled time dwell permits wider use of air or hydraulic power in automatic operations, increases accuracy of work by insuring split-second accuracy of the dwell. Available with 5 actuating lever linkages as shown.

Switch mounted to provide dwell at end of power stroke of single action, spring return cylinder.



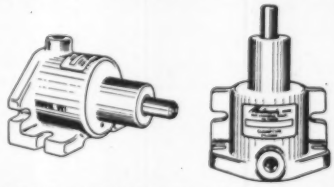
Pneu-Trol DEVICES, INC.
1434 N. KEATING AVENUE • CHICAGO 51, ILL.

Circle 666 on page 19

Modernair

CLAMP-TYPE AIR CYLINDERS

Easiest to install or relocate!



UNIVERSAL MOUNTING for easy vertical or horizontal installation.

SLOTTED MOUNTING HOLES save installation, relocation time.

SPRING-RETURN TYPE CYLINDER operates from simple 3-way valve (MODERNAIR CRV or BV series recommended). Has ⅛" NPT port.

ECONOMICALLY PRICED, TOO!

Bore Size	Price (f.o.b. factory) 1" Stroke	2" Stroke
1⅛"	$ 8.50	$ 9.75
2"	16.00	19.00
3"	23.50	26.50

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*made to S.A.E. and Federal Govt. Specifications

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CONTINENTAL FELT COMPANY, INC. 1903

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Circle 668 on page 19

the SIZE you want... the CAPACITY you want... at the PRICE you want...

Sier-Bath FLEXIBLE GEAR COUPLINGS

the SIZE you want..

Sier-Bath Couplings are smaller, lighter, stronger, simpler in design. Size range is virtually unlimited. Stocked models available from ⅞ to 12 to accommodate most bores on machine and power units. Unusual requirements can be met on order . . . and at low cost!

the CAPACITY you want..

Though smaller and lighter than conventional flange-and-bolt types, Sier-Bath Flexible Gear Couplings have greater horsepower capacity, size for size! Ranges are from 4 to 4500 hp per 100 rpm. Need high speed? Frequent start-stop-reverse? Frequent couple-uncouple? Have cramped quarters? Corrosive atmosphere? Sier-Bath Couplings carry the load!

the PRICE you want..

The extremely simple design of Sier-Bath Couplings not only pays dividends in flexibility of application but also results in lower initial costs . . . *averaging 21-percent below other leading brands!* You also save in less down time, longer life, faster assembly and uncouple, elimination of expensive tools.

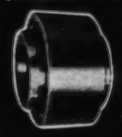
Get the full story on Sier-Bath Couplings by writing for our complete catalog. We'll be happy to quote on standard or special types, as well.

Sier-Bath GEAR and PUMP CO., Inc.

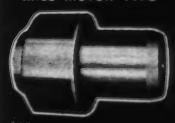
9254 HUDSON BLVD., NORTH BERGEN, N. J.

Founded 1905 Member A.G.M.A.

STANDARD TYPE

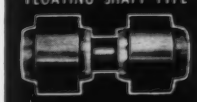


MILL MOTOR TYPE

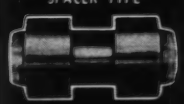


VERTICAL SHAFT TYPE

FLOATING SHAFT TYPE



SPACER TYPE



SPECIAL TYPES:

AIR HOSE CONNECTED • INSULATED • JORDAN • RIGID • CUT-OUT • SLIDING HUB • VERTICAL FLOATING SHAFT • CONTINUOUS LUBRICATED

Circle 669 on page 19

XUM

"MONOBALL" Self-Aligning Bearings

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All World Rights Reserved

CHARACTERISTICS

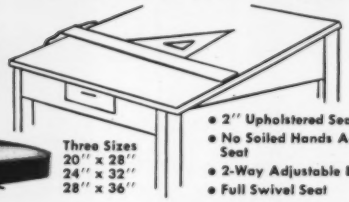
	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 8/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-56.

SOUTHWEST PRODUCTS CO.
DUARTE, CALIFORNIA

Circle 670 on page 19

AJUSTRITE® DRAFTING CHAIR



Three Sizes
20" x 28"
24" x 32"
28" x 36"

- 2" Upholstered Seat
- No Soiled Hands Adjusting Seat
- 2-Way Adjustable Back Rest
- Full Swivel Seat

Model RUC 2230

Just Right for
COMFORT • UTILITY • PRICE

The AJUSTRITE CHAIR enables the user to quickly and easily adjust the height of the seat up or down to suit his individual requirements—without soiling his hands.

The 2-way posture adjustment of the back rest assures a relaxed position free of strain and tension.

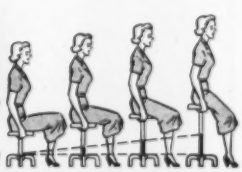
Also available with round metal or wood seat, formed plywood or solid hardwood saddled seat. Gray or green finish optional.

AJUSTO EQUIPMENT CO.
2144 Madison Ave. Toledo 2, Ohio

FREE TRIAL

Use AJUSTRITE Chair or Stool for 30 days without obligation. Prove to yourself the many advantages AJUSTRITE offers. Guaranteed against failure due to defective material or workmanship for a period of 10 years.

SPLIT SECOND
ADJUSTMENT
. . . to any Height Desired



Circle 671 on page 19

SELF-GRIPPING • SELF-LOCKING

PATENT APPLIED FOR

P-M NUT

CUTS COST, SPEEDS ASSEMBLY . . . ELIMINATES WASHERS, WRENCHES

High-quality, low-cost nut is made of spring-tempered high carbon steel or of tempered aluminum. Has cut threads and a flange with turned-down corners which bite into material to which applied. Spring flange is deflected during tightening for vibration-proof assembly. Used by leading manufacturers. Available in sizes 6-32 through 10-32. Other sizes in process.

P-M ROLL-FREE DRAWN STEEL STUD

Effects unusual savings over solid studs for most roller mounting. Standard sizes in steel, stainless steel or brass or to your specifications.

STAMPINGS

We have combined plant and equipment with engineering skill to provide accuracy, economy and service to many industries which use volume production. We can do so for you, too. Send samples or prints for quotations.

Write for FREE Literature and Samples

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Circle 672 on page 19

New...

Bondable Teflon* and Rulon®
in tape, film, other forms

Most people thought Teflon and Rulon could never be strongly bonded or cemented to other materials. No solvents affect them — no common chemicals attack them — they are extremely slippery and non-adhesive.

Dixon is now supplying Bondable Teflon and Rulon — and in thin strips and film that may greatly reduce your costs.

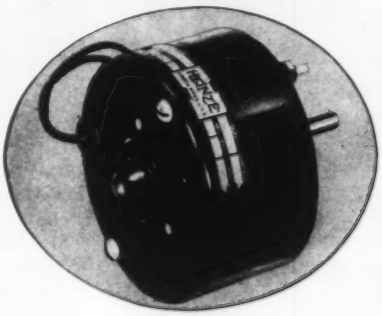
Write for 8 page bulletin

*Dupont's tetrafluoroethylene resin

DIXON Corporation
BRISTOL RHODE ISLAND
Est. 1876

Circle 673 on page 19

HEINZE
SUB-FRACTIONAL HORSEPOWER
MOTORS



Type Y

Four pole, Shaded pole Induction Motor
3¼" diameter 1/100 to 1/40 HP
115 or 230 volts 50 or 60 cycles
Free speed, 1700 RPM
Load speed, 1550 RPM
Can be furnished with internal fans for cooling.

Heinze Electric Co
685 Lawrence Street. LOWELL. MASS

Circle 674 on page 19

ALCOA
UTILITUBE
saves up to
40%
over copper

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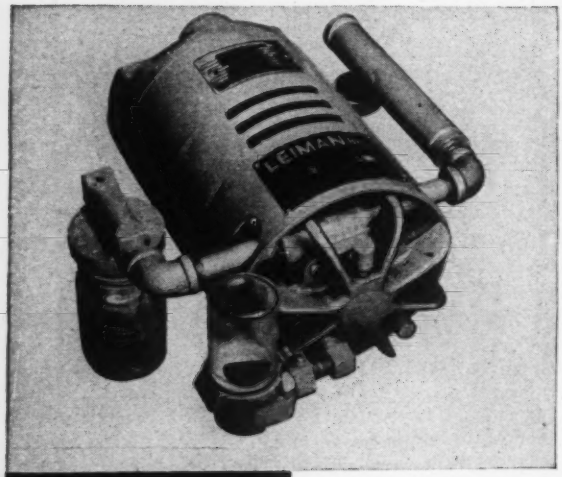

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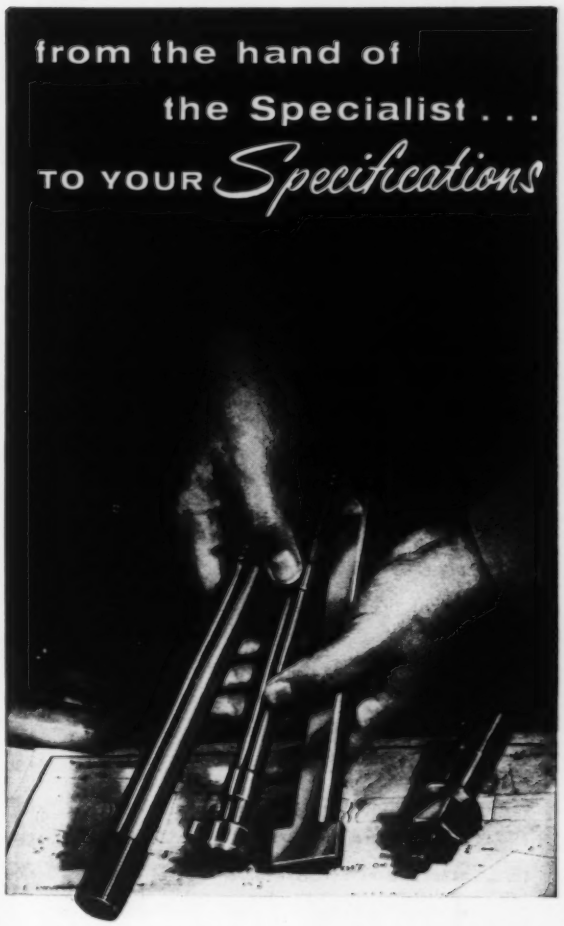

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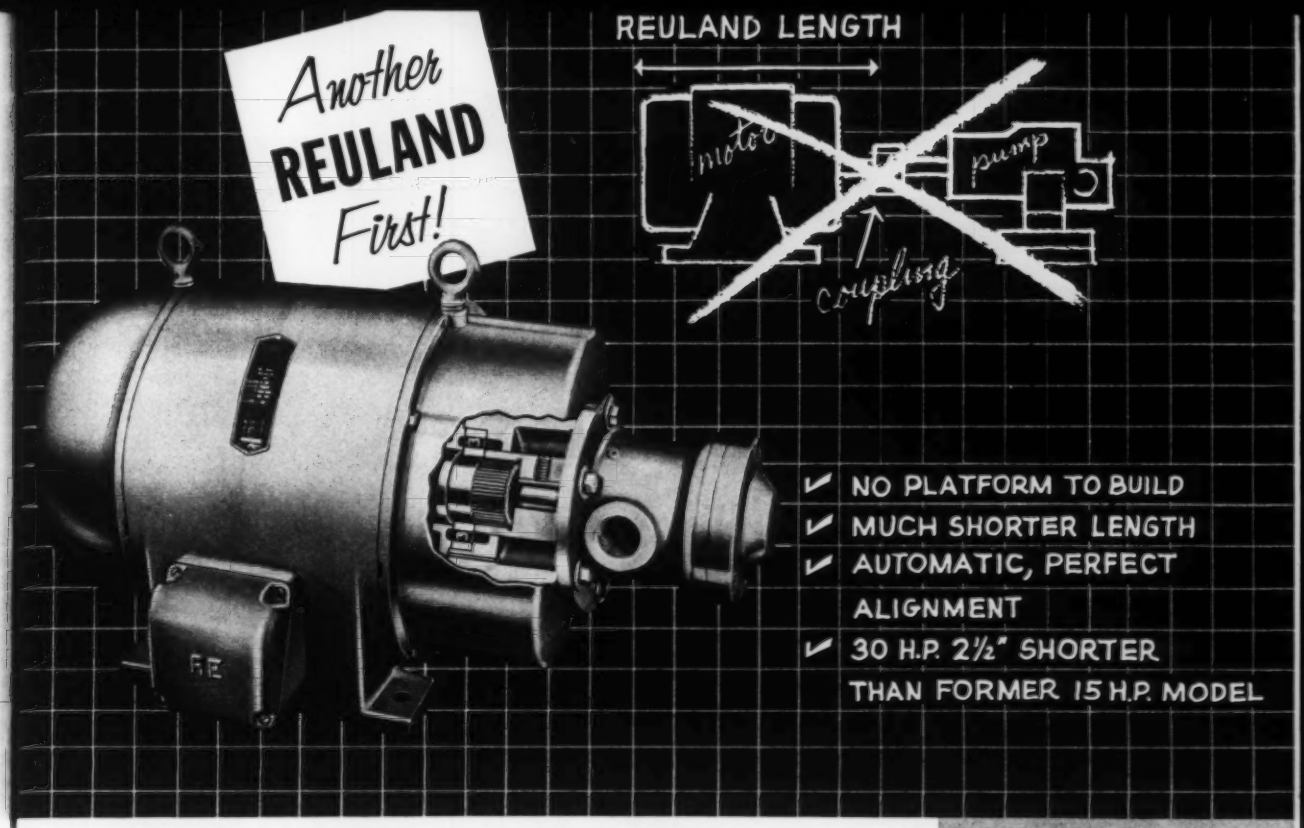

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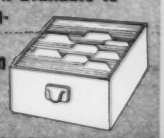

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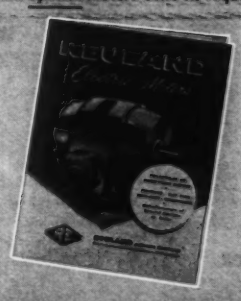

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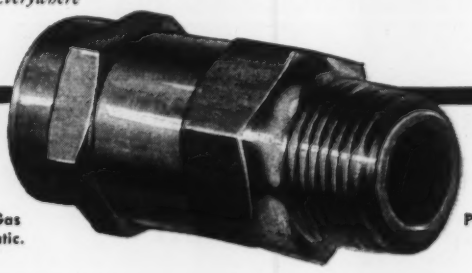


Welsbach Temperature-Pressure Relief Valve.

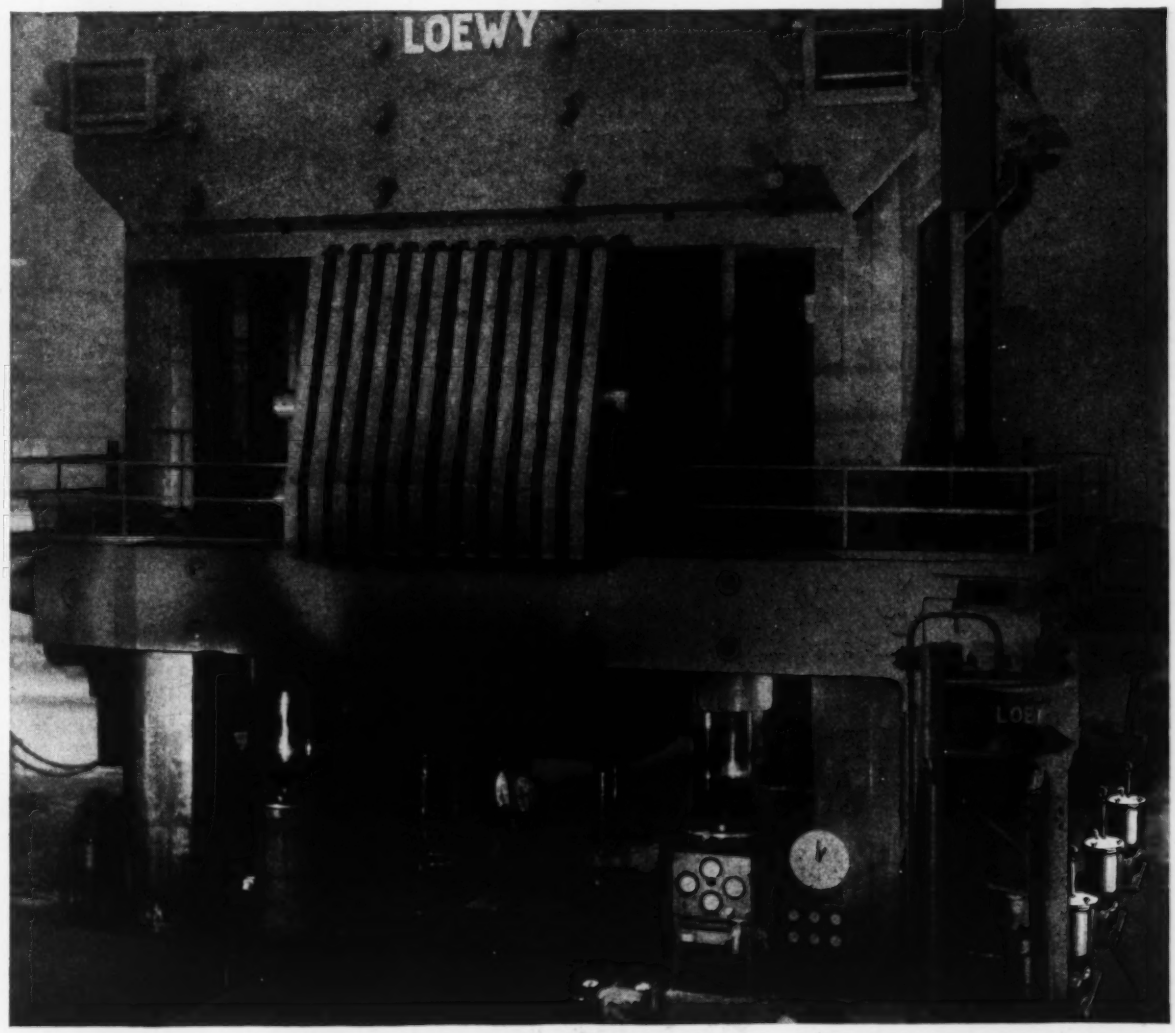
Welsbach Emergency Gas Shut-Off Valve, automatic.

Pressure Relief Valve for water heaters.

Circle 684 on page 19

Loewy 50,000-ton "Major" forging press is automatically lubricated by Farval

FARVAL—
Studies in Centralized Lubrication
No. 196



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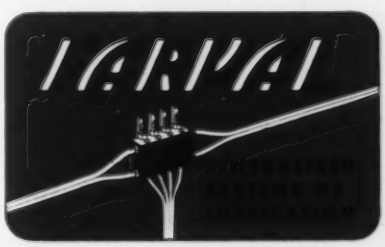
Wherever you see a Farval central pumping station, dual lubricant lines, and valve manifolds, you know a machine is being properly lubricated.

Three Farval heavy-duty automatic pumping stations that lubricate "Major" are to be seen at lower right.



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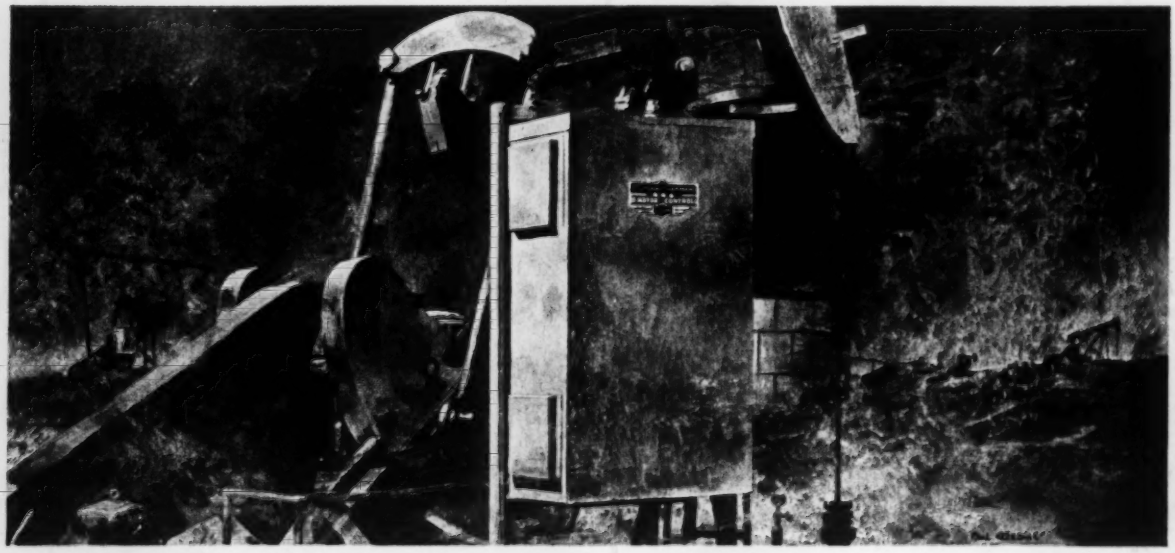
WHAT'S NEW IN MOTOR CONTROL? ☆ ☆ ☆ GET IT FIRST IN CUTLER-HAMMER

New Cutler-Hammer Three-Star Motor Control brings full automation to oil well pumping



If automation means completely automatic operation, oil well pumping has it today. With a remarkable new Cutler-Hammer Three-Star Motor Control unit, oil wells can now be pumped on a pre-set schedule to meet any field allowable . . . completely unattended *indefinitely* as far as the programming or the electrical equipment is concerned. When a power outage occurs, any number of pumps restart in a fixed sequence to prevent overloading the power lines. The control is protected against lightning and the motors are protected against single-phasing which often results from lightning. Blistering heat, ice, bugs or dust hold no terrors for this control designed to thwart them.

The heart of this new control is the Cutler-Hammer Supertimer. It does two things. First, it provides the means for setting the desired pumping schedule (hours per day and days per week). Second, it provides 73 accurately *controlled* restarting intervals (restarting time delays from zero seconds to as much as three minutes) to provide *definite* sequence starting of any number of pumps after any power interruption. Nothing is left to chance; unfortunate coincidental restarting of even two pumps is *impossible*. In addition, a small switch on the panel permits instant conversion from automatic to manual restarting whenever it might be desired. This control has *everything*, particularly the engineered dependability so vital in any automation.

Engineers know this is the way Cutler-Hammer designs and builds motor control. It is evident throughout the new complete line of Cutler-Hammer Three-Star Motor Control. If you are a user of industrial electric motors, it deserves your *immediate* investigation. Its easier installation often affords almost unbelievable savings. Its better performance will save much costly trouble. Its amazingly longer life pyramids its economies. Try it. Compare it. Prove it. Your nearby Cutler-Hammer Authorized Distributor is stocked and ready to serve you. Order from him *now*.

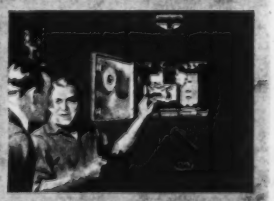
CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

2225N

Cutler-Hammer Three-Star Motor Control is available in every needed form

Cutler-Hammer Authorized Distributors carry stocks of Cutler-Hammer Three-Star Motor Control in sizes and types of enclosures to meet all normal industrial control requirements.

Leading machinery builders equip their machines with Cutler-Hammer Three-Star Motor Control as standard original equipment. All components are available for panel mounting.



Cutler-Hammer Three-Star Unitrol provides for easiest and quickest installation or rearrangement of the finest in control equipment, Cutler-Hammer Three-Star Motor Control.

☆ *installs easier*
☆ *works better*
☆ *lasts longer*

CUTLER-HAMMER
☆ ☆ ☆
MOTOR CONTROL
C-H

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